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RECENT ADVANCES IN AGRONOMY OF GROUNDNUT (*ARACHIS HYPOGAEA*)

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ABSTRACT

As an important edible oilseed crop, groundnut contributes 60 % of the total oil production in the country. The crop is grown predominantly under rainfed condition in *kharif*. The productivity however, is relatively low in kharif as compared to Rabi/ summer season crop owing to various factors relating to climate, soil and resource management. In this comprehensive review an attempt had been made to discuss groundnut production potential in relation to various factors such as soil, type tillage, seeding time, seed treatment, plant density, fertilizer management with particular reference to major nutrients like nitrogen phosphorus potassium, secondary nutrients such as calcium, magnesium and sulphur, and micronutrients like zinc Iron, boran. Apart from this, weed managemnet, irrigtaion water management and groundnut-baed intercropping systems with oilseed crops, pulses, cereals, and commercial crops are also covered.

Key words: Groundnut; Fertilizer management; micronutrients; Intercropping; weed management; water management.

INTRODUCTION

Of the nine important oilseed crops, groundnut contributes nearly 60 per cent of the total edible oil production. It is grown over an area of 7.5 million hectares with production of 6.9 million tonnes. About 84 per cent of the groundnut area in India is sown in the *Kharif* season underrainfed conditions. Due to variations in climate in *Kharif*, productivity is not stable and is low (748 kg/ha) as compared to *rabi*/ summer season (1515 kg/ha). In addition to this farmers are not adopting improved production technology viz., use of good quality seed of improved variety, seed treatment, time of sowing, proper use of manures and fertilizers, optimum spacing and plant density, weed control and profitable cropping systems. Recently it's cultivation has been extended under irrigation especially in multiple cropping system. A practice of growing groundnut in rice fallows has been developed in the states of Karnataka, Orissa, Andhra Pradesh, Tamil Nadu and Kerala.

2. Soils

Groundut is grown on all types of soils in India, such as sandy, sandy loam, loam, alluvial as well as clay soils. However, an ideal soil for groundnut production is a well drained, light coloured, loose friable, sandy loam well supplied with calcium and a moderate amount of organic matter with good water holding capacity. Illdrained, heavy and stiff clays, saline and acid soils have to be avoided for groundnut. In Karnataka, Orissa, Andhra Pradesh and Tamil Nadu groundnut is extensively grown in coastal sandy-loam soils under residual soil moisture during December to March. Irrigated groundnut is grown on sandy loam soils in Andhra Pradesh, Tamil Nadu, Karnataka and in medium black soils in Gujarat and Maharashtra.

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3. Tillage

Experiments conducted at Indian Agricultural Research Institute, New Delhi indicated that ploughing deeper than 15cm is not necessary for obtaining high yield in sandy loam soils. It is considered sufficient to secure good surface tilth to a depth of 12.5 to 18cm for ground nut. In Pollachi area of Tamil Nadu cultivators plough the soil after every good shower during the period from October to March. The growers in this zone have realised that more than manuring, good cultivation is very essential for this crop.

'Experimental evidences indicate that throwing the field into ridges and furrows and raised beds is preferable to flat beds under irrigated farming, in areas receiving heavy rainfall, regions of shallow water table and saline soils. ICRISAT has developed a broad and furrow (BBF) system of planting groundnut. In this method after every 4 or 3 rows of groundnut spaced at 30 cm, one row is left blank and it can be converted as irrigation or drianage furrow, and in between two furrows, bed is raised by about 10-15cm (ICRISAT, 1987) This sytem offers many advantages like drain off the excess rainfall, for irrigation and reduce the soil erosion in vertisols. Under irrigated condition at Dharwad, skipping a line after every three lines of sowing gave about six percent increased pod yield over the control. (Chandrasekhara Reddy, 1976).

4. Time of sowing

The rainfed crop is sown with the onset of South-West monsoon. It is necessary to sow the seeds after the soil has been well soaked with moisture and the temperature of soil is optimum for germination. Sowing rainfed and irrigated crops early in the season is most conducive for proper growth and high yields. Late planting always results in low yields. A delay in sowing at 7 days interval from 17th July to 24th August resulted in linear decrease in pod yield of groundnut. High seedling vigour during early stages of crop growth up to the pod filling stage maintenance of high leaf area duration from pod filling stage to maturity and efficient translocation of photo-synthates (high harvest index) were the major physiological parameters responsible for high yields from early sowing (Moorthy and Rao, 1986).

In normal sown crop (July 1st week) the pattern of flowering was regular with two distinct peaks of flowering. Maximum flowering was observed during 38 to 44 days after sowing and second spell of flowering occurred 12 to 15 days after first flush. In late sown crop (end of July) the pattern of flowering was erratic, there being no distinct flushes and less number of flowers produced upto 40 to 45 days indicates low yielding ability (Mallikharjun Reddy *et al.*, 1990). The best period for sowing the *rabi* crop which is raised on residual soil moisture is November, as sowing in the September and October leads to poor growth had low yield. The irrigated Summer crop is best sown from December to end of January for obtaining high yields.

5. Selection of seed and seed treatment

Quality of the seed is most important factor in groundnut. It has been observed that about 30 per cent of seeds sown in the field either do not germinate or after

germination due to low seedling vigour fail to establish into healthy plants. The problem of loss of viability is more in *rabi*/summer produce since within four to five monhs of storage about 50 per cent of seeds loose viability. The *kharif* produce can retain viability for longer period than *rabi*/summer produce (Nautiyal *et al.*. 1990). Drying of pods after harvesting is very important process which influences seed viability. The loss of viability in *rabi*/summer produce can be reduced by shade drying (Zade *et al.*, 1987).

Cultivars belonging to virginia group usually show prolonged seed dormancy, such seeds sown in the field within a short span of time after harvest leads to poor germination and uneven crop stand. Seed treatment with 0.1 per cent ethrel and combination of ethrel with thiram were found to be more effective in improving germination. Thiram slurry treatment was also beneficial in reducing the dormancy by 50 per cent (Nagarjun, 1979). Other growth regulators GA, Kinetin, IAA and IBA can be used to increase the germination in virginia group groundnut seeds.

The bunch type of groundnut is generally grown during *kharif* season as rainfed crop and in summer season as irrigated crop. When crop reaches maturity during *kharif* invariably rains occur and seeds in the pod starts germinating and heavy loss occurs. This problem is severe in black soils having more moisture holding capacity. Foliar spraying of 250-1000ppm of Malic Hydrazide at 60 and 75 days after sowing induces seed dormancy to an extent of 60 to 80 per cent. The induced dormancy was retained for a period of 3 weeks after the harvest of crop (Nagarjun, 1979).

It is essential to treat the seed with fungicides immediately after shelling of pods. The seeds are treated with captan or thiram or Dithane M-45 at 3-5 g/kg of seed for protecting the crop by controlling certain seed borne diseases. At Dharwad treating the seeds with thiram @ 3 g/kg seed and soil treatment with heptachlor at the rate of 25 kg/ha resulted in 23 per cent increase in pod yield (Agasimani *et al.*, 1983).

Since groundnut being very much specific to different types of Rhizobia, it may require to be inoculated with right strain having considerable competitive advantage over native strains (Gaur *et al.*, 1974). Jeg-1 Rhizobium strain has increased the yield significantly as compared to control (Table 1).

6. Spacing and plant geometry

Maintenance of optimum plant population is the key to success in groundnut cultivation. In India patchy stand of the crop is one of the main reason for poor yield of groundnut. In India groundnut is sown either by country seed drill or behind the plough (Reddy, 1988).

Groundnut requires an optimum space for the maximum exploitation of their inherent yield potential. However, beyond certain limit, yield cannot be increased with increasing plant population. Spanish bunch type is grown over 70 per cent of the area under groundnut. In bunch type, most of the pods are formed within a radi-

TABLE 1. Effect of seed treatment with Rhizobium on groundnut yield (Gaur *et al.*, 1974).

Rhizobium strain	Nodule Number	Pod yield (q/ha)	% increase over control
Control	44	18.8	—
Jeg-1	69	28.5	52.00
Jeg-2	51	18.7	-0.53
Jeg-3	55	22.1	17.00
Jeg-4	58	23.7	26.00
Jeg-5	42	18.7	-0.53
C.D. at 5%	4.8	0.99	—

ous of 10cm from tap root. There is no need to provide intra-row spacing more than 10cm. In assured rainfall areas and irrigated conditions 10cm spacing within the row is optimum, with seed rate of 100-150 kg/ha in spanish bunch groundnut. During *kharif* in medium black cotton soils, higher pod yield can be obtained from narrow spacing (30cm × 10cm) as compared to wider spacing of 30cm × 20cm or 40cm × 20cm (Agasimani *et al.*, 1984; Gopalswamy *et al.*, 1979; Chandrasekhar Reddy, 1976; and Biradar, 1982).

Closer spacing of 22.5cm × 10cm has recorded higher pod yield (4473 kg/ha) during *rabi* under irrigated conditions at Bhavanisagar on sandy loam solis (Jagannathan *et al.*, 1974). Similarly Saini and Tripathi (1979) reported that, average yields of unshelled nuts were the highest (3.30 and 3.26 t/ha) at 15cm × 16cm and 15cm × 8cm spacings respectively.

In addition to plant density, plant geometry of a crop is also widely recognised as one of the agro-techniques for increasing yield per unit area. The highest pod yield of 4088 kg/ha was recoided with a spacing of 20cm × 15 cm and next best was 20cm × 10cm spacing (3893 kg/ha). The plant geometry of 20cm × 15cm and 20cm × 10cm were found to be better than already adopted plant geometry of 30cm × 10cm, since in both the cases (30cm × 10cm and 20cm × 15cm) seed requirement and plant population remains same but an additional yield of nearly 417 kg/h of pod yield can be obtained in spanish bunch Cv. Dh-8 (Agasimani *et al.*, 1989).

The stand geometry of 20cm × 5cm has given 34% higher yield as compared to local practice if sowing behind the plough in sandy loam soils under receding soil moisture conditions in costal Karnataka (Agasimani and Hosmani, 1989a).

In virginia spreading groundnut wider row spacing of 75cm was proved to be superior under dry land farming areas of Bijapur (Patil, 1984).

7. Manuring

Application of organic manure is desirable to reduce surface crusting and compaction of soils and to improve the moisture holding capacity of the soil. Application of 7.5 tonnes of FYM/ha has increased the pod yield by (68% over control and 27 and 15 per cent over application of 25:50:25 and 50:100:25 kg N,P_2O_5 and K_2O/ha (Agasimani and Hosmani, 1989b).

8. Fertilization

The nutritional needs of the groundnut must be satisfied to attain maximum yields. Groundnut is an energy rich crop, but it is grown under energy starved conditions. It is found that from 1 g of glucose about 0.83 g of starch, 0.40 g of protein, and only 0.32 g of lipids are produced (Rao, 1984). An average crop of groundnut yielding 19 q/ha removed about 170 kg N, 30 kg P_2O_5 and 100 kg K_2O/ha (Aulakh *et al.*, 1985).

8.1. Nitrogen

Being a legume, the groundnut is able to obtain nitrogen through its symbiotic association with *Rhizobium*. This is not to say that application of nitrogenous fertilizer is not required, but that lower doses of nitrogen would be sufficient to raise a good crop. Many workers have obtained yield responses with relatively low rates of N, ranging from 20 to 33 kg/ha (Puntamkar and Bathkal, 1967; Phanishai *et al.*, 1969 Bhan and Mishra 1972) on both red and black soils. A common factor among these studies was that there was also a response to phosphorus in each and the greatest response was usually from a combination of N and P.

Seed inoculation in combination with 25 kg N/ha has significantly increased the growth and pod yield of groundnut (Singh and Ahuja, 1985). Similarly Romero (1975) reported that application of 25 to 30 kg N/ha is optimum for groundnut. Appli cation of higher nitrogen (50 kg N/ha) has significantly increased the number of branches per plant induced rapid growth and early flowering leading to better extraction of available soil moisture and maintenance of higher water content in leaf tissue (Suraj Bhan and Mishra 1972; Mohamad Ali *et al.*, 1974). Saini and Sandhu (1973) observed that application of 15 kg each of N and P per ha increased the pod yield by 20 per cent over control. Dahatonde (1982) noticed that pod yield of groundnut has significantly increased with application of 60 kg N/ha. Apart from soil application, foliar spray of 2% urea solution and 0.5% ferrous sulphate at 30 and 75 days after sowing increased the pod yield by 3.71 and 4.62 t/ha respectively (Panchakhsaraiah, 1985).

Groundnut grown on *stylo* (*stylosanthus hamata*) based soils, stylo contributed to fertility built up to the extent of yield contribution of 50 per cent recommended level of fertilizer of 25 kg N and 50 kg P_2O_5 (Khot *et al.*, 1990).

8.2. Phosphorus:

Response to phosphorus can be obtained when the available pohsphorus in the soil is less than 35 kg P_2O_5/ha. Response to the applied phosphorus is reported by

many authors. In Hyderabad in Andhra Pradesh, Kumar and Venkatachari (1971) noticed linear increases in average yield of unshelled nuts from 2.7 to 4.81 t/ha, by increase of phosphorus from 30 to 90 kg/ha. Similar observations were made by Singh and Ahuja (1985). Application of P_2O_5 at the rate of 60 kg P_2O_5/ha had nearly doubled the yield of groundnut as compared to control (Dudde *et al.*, 1980). On clayey soils, application of 50 kg P_2O_5/ha alone and in combination with 25 kg Sulphur has significantly increased the pod number, dry matter and nitrogen content of nodules (Sagare *et al.*, 1986). An encouraging response to applied phosphorus was also reported by Muralidharan and George (1971), Muralidharan *et al.*, (1975) and Shelke and Khuspe (1980.)

Ishag and Said (1985) observed that higher level of nitrogen (86kg N/ha) and 43 kg P_2O_5/ha increased the pod yield significantly. Phosphorus tended to cause early flowering and pegging, and nitrogen increased phosphorus uptake, in irrigated Vertisols. Among different sources of phosphorus, single super phosphate is the best source, as it contains besides phosphorus (16%), Calcium (19.5) and Sulphur (12.5%) which are very essential for groundnut.

8.3. Potassium

A good crop of groundnut removes considerable amount of potassium from the soil but most of the soils are rich in potassium. Response to potassium can be obtained when the available K_2O in the soil is less than 150 kg/ha. A dose of 40kg K_2O/ha under rainfed conditions and upto 70 kg K_2O/ha under irrigated conditions is recommended depending upon the available K_2O status of the soil (Sankara Reddy 1982). Response to K application varied from 20 to 90 kg/ha at different places, (Romero 1975, Nadagouda *et al.*, 1980, Babu *et al.*, 1985).

Agasimani and Hosmani (1989b) reported that, in west coast of Karnataka on sandy loam soils under receding moisture conditions a combined application of 50 kg N, 100 kg P_2O_5 and 25 kg K_2O per hectare resulted in 46% increased pod yield over control. The soil was characterized by a pH of 5.8, organic carbon 0.58% available phosphorus 80 kg/ha, and available potash 375 kg/ha.

8.4. Calcium, Magnesium and Sulphur

Calcium and Sulphur are considered together, as both are taken up from the pod (fruiting) zone by the peg, and developing pods, and the cheapest source of supply of these two nutrients is the same. Gypsum is the cheapest source of calcium and sulphur which contains 29.2% and 18.6% of these elements, respectively. Groundnut yielding 19 q/ha will remove 15 kg S, 39 kg Ca and 20 kg Mg/ha (Aulakh *et al.*, 1985). About 1 meg exchangeable Ca/100g soil in the root zone and three times this much in the pod formation zone are considered as threshold values.

The translocation of calcium is only one sided i.e. from pods to vegetative parts. Experiments conducted by Bledsoe *et al.*, (1949) and Bledsoe and Harris (1950) showed

that Ca is absorbed by both roots and gynophores, but only a trace of it absorbed by roots moves to fruits; while a considerable part absorbed by pods is translocated to vegetative parts. Similarly when labelled calcium was fed to the fruiting-zone it was observed that 88.3% of Ca was retained by pods and in traces by vegetative parts. When the same was fed to the rooting zone 66% was retained in the leaves and 13.8 per cent in the pods (Chahal and Virmani, 1973). Several authors suggested application of calcium to the pegging zone at first stage of flowering (Nijhawan and Mani, 1966; Mizno, 1960; Radder and Biradar, 1973; Patil, 1975; Roy *et al.*, 1980, and Allison, 1985).

TABLE 2. **Pod yield of groundnut as influenced by plant geometry (Agasimani *et al.*, 1984).**

Spacing (cm)	Pod yield (q/ha) (Mean of 1984, 1985 & 1986)
10 × 10	31.6
10 × 20	36.9
20 × 10	38.9
20 × 15	40.9
20 × 20	36.2
30 × 10	36.7
30 × 20	32.0
40 × 20	31.4
S.Em±	2.46
C.D. at 5%	5.03

In acid soils of pH 5.1 application of one tonne of lime and 0.3 tonne of gypsum per hectare increased the yield of pods by 660 and 540 kg, respectively over control (Satyanarayana *et al.*, 1975). Radder and Biradar (1973) reported that band placement of gypsum in the pegging zone at the rate of 500 kg per hectare at 30 days after sowing increased the number of developed pods per plant by 16.7 per cent and pod yield 19.8 per cent. However, the response of groundnut to gypsum application varied from 250 to 2000 kg/ha (Reddy and Patil, 1980; Rao *et al.*, 1984 and Allison, 1985).

In coastal belt of Uttara Kannada district on sandy loam soils in rice fallows, application of 500 kg per hectare gypsum at flowering stage in the pegging zone gave 46 per cent enhancement in pod yield (Table 3) over no application (Agasimani, 1988). This increase in the pod yield is mainly due to increased growth rate and yield components like plant height, number of branches, number of developed pods per plant, haulm yield at harvest, 100-kernel weight, shelling percentage and per cent of sound matured kernels. Split application of gypsum as basal and at flowering significantly increased the pod yield, number of filled pods per plant, 100-kernel weight and volume weight (Chitkaladevi *et al.*, 1988).

TABLE 3. Pod yield of groundnut as influenced by gypsum application (Agasimani, 1988).

Treatments gypsum (kg/ha)	Pod yield (q/ha)			Mean
	1983-84	1984-85	1985-86	
Control (0 kg/ha)	18.8	7.2	21.4	15.8
500 kg/ha at sowing	20.5	8.1	26.2	18.3
500 kg/ha at pegging	23.6	16.4	28.6	22.9
1000 kg/ha at sowing	20.2	8.8	26.2	18.3
1000 kg/ha at pegging	22.0	9.3	25.0	18.8
250 kg/ha at sowing and 250 kg/h at pegging	22.6	15.8	26.2	21.5
500 kg/ha at sowing and 500 kg/ha at pegging	20.8	15.9	26.2	21.0
S. Em±	1.04	5.2	4.5	1.6
C.D. at 5%	2.27	11.3	NS	NS

Sulphur is important for the synthesis of fat. It helps in biological oxidation-reduction processes. Acid soils are very poor in sulphur. Soils with less than 10 ppm available sulphur are considered deficient for groundnut. Sulphur deficient plants have low chlorophyll content. Soil application of 250 kg/ha gypsum which contains 18.6% sulphur is able to correct the deficiency and increase the pod yield. Sulphur is taken up by the pegs penetrating into the soil and also the developing pods, but pegs take more sulphur. In field trials with groundnut on clay soils, application of 25 kg S, Plus 50 kg P_2O_5/ha significantly increased the number, dry matter and N content of nodules (Sagare *et al.*, 1986). At IARI on sandy loam soils of pH 7.8, the response to sulphur was significant upto 60 and 30 kg/ha during 1985 and 1986, respectively (Giri and Saran, 1989). An experiment conducted at Dharwad revealed that seed yield of groundnut was increased from 1.82 with only NPK application to 2.62 tonnes per hectare with the application of sulphur. Similar observations were made by Ramanathan and Ramanathan (1982).

8.5. Micronutrients:

Deficiencies in one of the other micronutrients limit groundnut production in some regions as for instance zinc in sandy and sandy loam soils; iron in calcarious black soils of Gujarat, Karnataka, Maharashtra; and Boron in Tamil Nadu. The uptake of Zn, Fe, Mn, Cu by groundnut crop yielding 19 q/ha was 208, 4340, 176 and 68 g/ha, respectively.

In Zn deficient soils, application of Zn increased the nodulation, chlorophyll content and pod yield (Saini *et al.*, 1975). Application of Zn, B and a mixture of 6 micronutrients increased the pod yield by 41.9, 34.3 and 80.0 per cent, respectively over

control (Pal, 1986)· Wherever soils are deficient, soil application of 25-50 kg/ha zinc sulphate or 0.02% zinc sulphate as foliar spray is suggested. A synergistic effect between Zn and S has been observed and application of 20 kg N and 15 kg S/ha has produced higher pod yield (Pasricha *et al.*, 1987).

The Chief source of Fe widly used to control Fe chlorosis is Fe SO_4 Savitri and Sriramulu (1980) should that soil application of 25 kg Fe SO_4/ha increased the kernel yield by 15.6 per cent over control on red sandy loam soils. However several workers are of the opinion that soil application of Fe SO_4 has not been found satisfactory because of their rapid oxidation to much less soluble Fe^{3+} ion.

Foliar application of Fe SO_4 at 30.60 and 70 days after sowing gave the highest pod yield of 2.98 t/ha, which was 11,16,20 and 24 per cent higher than that obtained by soil application of 2 tonnes gypsum 25 kg $ZnSO_4$ or 50 kg Fe SO_4/ha at 30,60 and 75 days after sowing respectively (Patil *et al.*, 1979) Similar observations were made by Panchaksharaiah (1985). Chelation of Fe slows down or even prevents the fixation or precipitation of Fe in soil (Saucheli, 1969). Beneficial effects of applying Fe-chelates to soil were observed by Hartzook (1982) and Panchaksharaiah (1982).

Plant genotypes differ in their ability to take up Fe from soil. Panchaksharaiah (1982) and Kulkarni (1989) observed genetic variability in groundnut for efficiency in Fe utilization. Cultivars Tatu, Dh-8, GG-2 were Fe efficient and TMV-2 and Dh-3-30 were found to be Fe inefficient (Kulkarni, 1989).

The threshold level of boron is 0.25 ppm. The deficiency can be corrected by the application of 5-10 kg/ha or 0.1 per cent borax depending upon the extent of deficiency (Table 4). Boron has a favourable effect on the number of effective pegs (Golakiya and Patel, 1986).

TABLE 4. Effect of $CaCo_3$ and boron on yield components of groundnut (Golakiya and Patel, 1986)

Yield Component	Levels of $CaCO_3$ (%)		C.D.	Levels of Boron (ppm)		C.D.
	Control	10%	(0.05)	Control	1.0	(0.05)
No. of matured pods/plot	63.9	70.3	2.4	66.0	67.9	2.5
No. of pods/pot	12.5	14.0	1.2	18.9	13.2	1.4
Percentage of pods	18.0	18.5	1.6	21.5	17.5	1.8
Pod yield (g/pot)	68.0	70.3	1.6	59.5	66.2	1.8
Shelling percentage	77.5	77.0	1.0	74.8	77.0	1.2
Nodule counts/pot	842.3	935.0	168.5	655.0	890.4	188.5

The results of field trials on laterite soils indicated that, application of 60 kg Ca or 60 kg S or 0.9 kg boron or 5.5 tonne FYM/ha alone or in combination increased the dry pod yield by 13-86 per cent. Increase was the lowest with Ca alone and highest with the fullest combination, followed by 53.9 per cent by Ca + S + B application. Oil content increased from 44.71 per cent in control to 47.61 per cent by FYM+S; and protein content increased from 24.46 to 27.24 per cent with FYM+Ca+S application (Survase *et al.*, 1986). Calcium sulphur and boron have a synergistic effect on micronutrient uptake. (Table-5).

TABLE 5. Yield and quality of groundnut as influenced by FYM, Calcium, Sulphur and Boron in Lateritic soil (Survase *et al.*, 1986).

Treatment	Dry pod yield (q/ha)	% increase over control	Shelling (%)	Wt. of 100-kernels (g)	Oil content (%)	Protein content (%)
Control	12.12	—	69.53	54.50	44.71	24.46
60 kg calcium (Ca)/ha	13.70	13.0	71.57	54.47	45.84	25.35
0.92kg Boron (B)/ha	15.60	28.7	71.03	54.95	45.92	24.88
60kg Sulphur (S)/ha.	15.28	26.0	72.45	56.30	46.39	25.52
5.5 tonne of FYM/ha (FYM)	15.98	31.8	71.85	54.74	45.49	25.18
Ca+B	15.28	26.0	72.36	55.75	46.10	26.05
Ca+S	18.21	50.2	72.67	55.91	46.73	25.41
B+S	17.46	44.0	72.22	56.07	46.52	25.93
Ca+B+S	18.66	53.9	72.11	56.59	46.32	26.77
FYM+Ca	17.69	45.9	72.90	56.30	47.16	25.54
FYM+B	17.09	41.0	72.23	57.26	46.40	26.16
FYM+S	17.84	47.2	73.24	56.96	47.61	26.23
FYM+Ca+B	15.80	30.3	72.33	56.02	45.23	26.00
FYM+Ca+S	18.14	49.6	72.54	56.56	46.60	27.24
FYM+B+S	17.16	41.6	72.43	56.65	47.07	26.47
FYM+Ca+B+S	22.50	35.6	72.77	56.92	46.72	26.39
S. Em±	1.08	—	1.06	0.62	0.36	0.32
C.D. at 5%	3.11	—	NS	NS	1.05	0.94

9. Weed control

Investigations revealed yield loss of 52 and 18 per cent in erect and spreading varieties of groundnut, respectively due to uncontrolled weeds (Kulkarni *et al.*, 1963)

In general, weed infestation in groundnut has reduced 25 to 50 per cent of pod yield (Singh and Moolani, 1967). Similarly, Praveen Rao *et al.* (1987) noticed maximum reduction in yield (70%) when weed control was not taken up. For controlling weeds and also to keep the soil in a friable condition, one hand,weeding and two or three hoeings are advocated, the first hoeing about three weeks after planting and subsequentlly at a fortnight interval. Earthing up can be done simultaneously in case of bunch and semispreading varieties to facilitate maximum penetration of pegs in the soil.

In view of the labour scarcity, expense and time involved, the use of herbicides, either alone or in combination with cultural methods to control weeds effectively, has become necessary. At Dharwad (AICRPO, 1987) on medium deep black soils, during *kharif* season, pre-emergence application of Nitrogen and Alachlor at 2.5 and 2.0 kg ai/ha respectively being on par with weed-free check (*3385 kg/ha*) has significantly increased the pod yield (3271 and 3264 kg/ha respectively) over control (1558 kg/ha).

Presowing incorporation of fluchloralin at 1.5 to 2 lit. a.i./ha, or pre-emergence application of oxadiazone at 1.5 kg a.i./ha or pendimethalin at 0.75 to 1.5 kg a.i./ha in combination with one hand weeding gave most effective weed control in irrigated groundnut and produced yield similar to that under weed-free conditions (Bhola *et al.*, 1985). Similarly pannu *et al* (1989) reported that pre-plant incorporation of fluchloralin 1.5 kg a.i./ha in conjunction with one hand weeding at 40 DAS controlled weeds effectively.

The maximum dry pod yield of 24.9 q/ha was recorded in weed free check which was at part with one hoeing (15-20 DAS)+one hand weeding (25-30 DAS), and fluchloralin 1.9 kg a.i./ha as pre sowing followed by one hoeing (Patil *et al.*, 1990). Jana *et al* (1989) observed that hand weeding at 15 and 30 DAS and application of Bentazon @ 1.51 kg a.i./ha increased the pod yield by 12.76 and 11.75% respectively over unweeded control. Pre-emergence application of pendimethalin at 0.75 kg a.i./ha+ intercultivation recorded the highest oil yield (9.36 q/ha) of groundnut (Girijesh and Patil, 1989). However, fluchloralin, Nitrogen and Oxadiazon as pre-emergence spray controlled weed population up to 30 DAS (Malvia and Patel, 1989).

Varieties differed significantly with respect to weed supressing ability. The genotype K-71-1 Virginia spreading type seemed to have suppressed the weed growth to about 50%.This was highest yielder undder weed-free as well as unweeded conditions. The next best varieties of spanish bunch types were J-11, TMV-2 and spanish improved. The velancia bunch groundnut genotype MH.2 allowed more luxuriant weed growth (Kondap *et al.*, 1988).

10. Irrigation

At present 16% of the area under groundnut is irrigated and it contributes 28% of the total production. Recently the area under groundnut has been extended under irrigation, specially in multiple cropping system. By growing *rabi*/summer groundnut the productivity can be increased from 10 to 25 q/ha. Considering the

expanding irrigation facilities in the country, it is quite possible to increase the area under summer groundnut from the present 12.27 lakh ha to 20 lakh ha by the turn of the century.

In southern states, rice-groundnut rotation is becoming increasingly popular under command areas. It has been established that four hectares of groundnut can be raised with the same quantity of water required for one hectare of rice.

10.1. Irrigation water requirement

Irrigation water requirement of crop vary with type of soil and climatic conditions of different places (Table 6).

TABLE 6. Irrigation requirement of groundnut at different locations.

Place	Soil type	Season	Irrigation Water requirement (mm)	References
Bhavanisagar	Red sandy loam	*Rabi*	500–700	Ali *et al.* (1974)
Madurai	Sandy clay loam	*Rabi* Sprinkler	387	Anon (1984)
		Surface	482	
Dharwad	Red sandy loam	Summer	600–700	Anon (1981)
Dharwad	Clay laom	Summer	600	Babalad (1986)
Hyderabad	Sandy loam	*Rabi*	547	Rami Reddy *et al.* (1980)
Parashani	Clay	Summer	550	Khuspe (1975)
Dhapoli	Clay	*Rabi*	550–700	Thorat *et al.* (1984)
Junagadh	Clay loam	Summer	550	Gajera *et al.* (1984)
Ludhiana	Sandy loam	*Kharif*	300	Saini *et al.* (1973)
Hisar	Sandy loam	*Kharif*	350	Singh *et al.* (1968
Chakuli (Orissa)	Loamy sand	*Rabi*	690	Lenka and Mishra (1973)

Consumptive use of water ranged from 44.2 to 67.4cm under different irrigation schedule. The highest water use of 67.4 cm was recorded with irrigation schedule of continuous 0.91 IW/CPE ratio on sandy loam soils of west Bengal during summer (Pahalwan and Tripathi, 1984). Relative moisture use was highest (43cm) in treatment receiving irrigation at 25 percent depletion of available soil moisture (Lenka and Mishra, 1973). Average consumptive use of water by groundnut was found to be 444 to 500 mm in TMV-2 and 426 to 505 mm in AH-1192 groundnut varieties on sandy loam soils at Tirupati (Sankara Reddi and Nageswara Reddy, 1977).

10.2. Depth of irrigation

For red sandy loam soils with low moisture retentive capacity, high frequency of irrigation (2 cm EP) with depth of water at each irrigation equal to that lost in USWB class 'A' pan evaporimeter was necessary to maintain optimum available soil moisture for normal growth (Table 7). The available soil moisture was maximum with high frequency of irrigation (Rami Reddy *et al.*, 1980). However, in clayey soils, irrigation to a depth of 6 cm produced significantly higher yield as compared to 2 and 4 cm of irrigation (CPRWM, 1977 and Khan and Datta, 1982).

TABLE 7. Effect of frequency and depth of irrigation on yield and yield attributes of groundnut (Ram Reddy *et al.*, 1980).

Frequency and depth of irrigation	No. of filled pods per plant	Shelling per cent	100-pod weight (g)	Pod yield-(Q/ha)	No. of irrigations	Total quantity of water applied (mm)
2	14.56	76.50	76.60	35.7	37	547.5
4	13.51	75.95	73.95	33.6	18	540.0
6	12.51	71.67	69.32	29.8	13	542.5
8	10.91	68.20	63.51	28.1	10	570.0
C.D. at 5%	0.846	2.54	1.59	1.1	—	—

10.3. Scheduling irrigation based on soil moisture regime

The optimum regime for scheduling irrrigation to groundnut grown on sandy loam soils is 25 per cent depletion of available soil moisture. Number of pods per plant and their weight on an average reduced with decrease in frequency of irrigation (Lenka and Mishra, 1973; Sankara Reddi and Nageswara Reddy, 1977 and Sabale and Khuspe, 1989). When water sources are limited, irrigation could be scheduled at 50 per cent depletion of ASM during early stages up to 50 days after sowing, and 25 per cent depletion of ASM there-after during pod development stage (Sankara Reddi, 1975 and CPRWM, 1978).

On *Vertisols* irrigation at 50 per cent depletion of ASM produced the highest pod yield (Saini *et al.*, 1973). Similar observations were made by Ali and Mohan (1974), Yadav (1975), CPRWM (1980), Ramesh babu *et al.* (1984) and Babalad and Kulkarni (1988).

10.4. Scheduling irrigation based on climatological approach

10.4.1. USWB class 'A' pan evaporation

Irrigation scheduled at 50, 75 and 100mm CPE recorded significantly higher pod yield of groundnut over 125 mm (Table 8). The pod yield of groundnut increased

TABLE 8. Dry pod yield of *groundnut* as *affected by* irrigation based on pan evaporation (Birajdar and Ingale, 1977).

Treatment	No. of irrigations	Pod yield (q/ha)	Haulm yield (q/ha)	WUE
Irrigation at 50 mm CPE	16	17.49a	47.32a	2.57
Irrigation at 75 mm CPE	11	18.59a	43.67b	3.44
Irrigation at 100 mm CPE	8	17.69a	42.10b	3.18
Irrigation at 125 mm CPE	6	13.87	25.28c	2.4
S. Em±	—	0.624	0.798	—
C.D. at 5%	—	1.995	2.552	—

from 13.87 q/ha to 17.49, 18.59 and 17.69 q/ha with irrigation scheduled at 50, 75, 100mm CPE over 125 mm CPE (Birajdar and Ingale, 1977). At Parbhani irrigation scheduled at 40 and 80 mm CPE increased the pod yield significantly over 120 mm CPE (Shelke and Khuspe, 1980). On sandy loam soils, irrigation scheduled at 20 mm CPE has given significantly higher pod yield (Rami Reddy *et al.*, 1980).

10.4.2. Can evaporimeter

There is close correlation between crop ET (groundnut) and evaporation from the Can and USWB Class 'A' Pan evaporimeters. The values for crop ET and USWB class 'A' pan evaporimeter were 0.980 and 0.971, respectively and from Can evaporimeter were 0.99 and 0.99 during 1977 and 1978, respectively (Rami Reddi, 1984).

High frequency of irrigation at 40 mm CCE (Cumulative Can Evaporation) at an interval of every 5 days gave maximum yield as compared to 20.60 and 80 mm CCE treatments on sandy loam soils. The quantity of water applied at each irrigation was equal to the amount lost from the can evaporimeter, hence the quantity of water applied in all the treatments is almost same (Rami Reddy *et al.*, 1982 and Rami Reddy, 1984). Where as on *Vertisols*, scheduling irrigation at 50 mm CCE has given significantly higher pod yield as compared to 75 and 100mm CCE (Babalad and Kulkarni, 1988).

10.5. Scheduling based on critical stages

The important growth periods for groundnut are:

0	establishment	10–20 days	
1	vegetative	25–35 days	
2	Flowering and pegging	30–40 days	
3	yield formation	30–35 days	
4	ripening	10–20 days	(FAO., 1979)

In groundnut the decrease in yield is proportionately less with the increase in water deficit during that growth period is small for vegetative period and ripening period, and relatively large for flowering, pegging and pod formation period. The flowering and pegging period is most sensitive to water deficit followed by yield formation period (FAO, 1979). The early part of the yield formation period is particularly sensitive to water deficit. In case of limited water supply water saving should be made during the periods other than flowering and early yield formation (Balasubramanian and Yayok, 1981). Irrigation scheduling with higher frequency i.e. 0.7 or 0.9 IW/CPE ratio during flowering, pegging and pod formation and 0.5 ratio during vegetative growth is advocated to get higher yield (Pahalwan and Tripathi, 1984). At Aliyarnagar, significantly higher pod yield was obtained when the crop was irrigated at peak flowering and pegging (50-70 DAS) than at pod development (70-90 DAS) and pod maturity (90-100 DAS) stages (AICRPO, 1988).

10.6. Methods of irrigation

It was found that considerable saving of irrigation water (24.7%) can be achieved by following sprinkler irrigation as compared to surface method of irrigation. The total water use in surface method of irrigation was higher (48.2cm) as compared to sprinkler irrigation (38.7cm). Besides, the yield of groundnut pods under sprinkler irrigation was 1987 kg/ha, which was 18.8% higher than the yield of 1675 kg/ha obtained under surface irrigation (CPRWM, 1984).

At Konkan Krishi Vidyapeeth on clay loam soils, sprinkler method of irrigation has increased the pod yield by 20.81% with 33% saving in irrigation water as compared to check basin method of irrigation (Kakde *et al.*, 1989). At Tirupati, however, Sprinkler method was found to be expensive, as the cost of production was Rs. 55.40/q as against Rs. 26.70/q in check basin method of irrigation (CPRWM, 1982).

Wheat straw mulch at 5 t/ha + Kaolin remaining at par with straw mulch gave higher pod yield than control. The highest dry weight of weeds was observed with no mulch, which differed significantly with mulch and mulch + Kaolin. The highest water use efficiency was also observed in Kaolin + mulch treatment (Joshi *et al.*, 1987).

10.7. Economization of irrigation water

Efficiency of soil moisture use can possibly be increased if evapotranspiration losses are minimised. Rice straw mulch was found superior to rice husk mulch and it recorded significantly higher pod yield over no mulch, which saved two irrigations (Mandal and Ghosh 1984). The use of energy reflecting material like kaolin as foliar spray effectively reduced the transpiration by 17.25%. Under non-stressed condition, shoot and root dry matter accumulation was not affected by kaolin spray. Under medium stress, kaolin increased the shoot and root dry matter by 24.84 and 26.39 per cent, respectively. Under severe stress, the effect was still more pronounced, as shoot

and root dry matter weight increased by 57.98% and 53.61 percent, respectively (Khan and Murey 1980).

11. Intercropping

The production of oilseeds can be enhanced by increasing the area under oilseeds or by increasing the productivity or by both. The area increase *per se* can be achieved without affecting food crop production through many ways, and intercropping is one way. There is now ample evidence that total yield increases are possible with intercropping over sole croppinng. One of the main reasons for such advantage is that the component crops are able to use resources differently, so that when grown together, they supplement each other and make better total use of resources than growing separately (Willey, 1979).

The research work has proved that intercropping of groundnut with sunflower, redgram, chilli, cotton, bajra, maize and *seteria* can be done (Table 9). It was observed that groundnut yield was significantly reduced in groundnut + cereal intercropping system, while it was unaffected in groundnut + oilseed and groundnut + pulse intercropping system (Nambiar *et al.*, 1983).

TABLE 9. Important intercropping systems suggested for different regions.

Region	Intercropping	Ratio of base crop (groundnut) to intercrop
Karnataka	Groundnut: Hybrid sorghum (Dharwad)	3:1
	Groundnut: Ragi (Bangalore)	6:1
	Groundnut: Redgram (Bijapur)	4:1
	Groundnut: Cotton (Dharwad)	3:1 or 5:1
	Groundnut: Chilli (Dharwad)	3:1
	Groundnut: Sunflower (Bijapur)	4:2
Tamilnadu	Groundnut: Sunflower	3:1
	Groundnut: Bajra	6:1
	Groundnut: Sesamum	4:1
	Groundnut: Castor	7:1
	Groundnut: Blackgram	6:1
	Groundnut: Cotton	5:1
Andhra Pradesh	Groundnut: Redgram	4:2
	Groundnut: Bajra	3:1
	Groundnut: Sorghum	3:1
	Groundnut: Castor	6:1
	Groundnut: Redgram	6:1
	Gorundnut: Pearlmillet	6:1
Maharashtra	Groundnut: Redgram (Rahuri)	3:1
	Groundnut: Safflower (Jalagaon)	4:2
	Groundnut: Sorghum	4:1
	Groundnut: Bajra	4:1 or 6:2
	Groundnut: Redgram	6:1 or 8:1
Gujarat	Groundnut: Pearlmillet (Saurastra)	1:1
	Groundnut: Sunflower (Saurastra)	1:1
	Groundnut: Sesamum (Saurastra)	1:1
	Groundnut: Castor	3:1 or 5:1
	Groundnut: Redgram	5:1 or 8:1

11.1. Groundnut with other oilseed crops

The seed yield of sunflower was not adversely affected due to intercropping with groundnut. The total productivity of the intercropping system was 74 per cent higher than the pure cropping of sunflower (Singh and Singh, 1977). Taking sunflower as an intercrop in groundnut in 2:6 row proportion was found to bring higher returns. Under unfavourable weather conditions, groundnut may fail but sunflower brings some returns. Under favourable weather conditions, both the crops in combination bring still higher returns as compared to single crop. The 'Morden' variety of sunflower was most suitable for intercropping with groundnut under dry farming conditions (Sindagi, 1982). At Dharwad, intercropping of groundnut and sunflower in 3:1 row proportion with 75:50 per cent population combination has recorded significantly higher oil yield (1.01 and 3.51 q/ha respectively). The total oil yield obtained under this combination was 27% higher than sole crop of groundnut with yield advantage of 37% (LET 3.37) (Yaragattikar, 1986). Similar observations were reported by Nikam *et al* (1984) and Venkateswarlu *et al.*, (1980).

Mehta *et al* (1985) reported that pod yield of groundnut was reduced due to intercropping with sesamum. However, total productivity was more in intercropping than the sole cropping. In Gujarat where traditionally a wide space of 90cm is adopted, sowing of short duration sesamum or sunflower is taken up 30 days after groundnut sowing to increase the total production of oilseeds. Intercropping of one row of sesamum in groundnut grown at 30cm × 5cm produced total oil yield of 787 and 852 kg/ha respectively compared to groundnut sole crop (Venkateswarlu *et al.* 1980). At Dharwad, groundnut + sesamum intercropping has not reduced the groundnut yield at 3:1 , 6:1 and 9:2 row proportions and gave higher monetary returns as compared to sole groundnut (AICRPO, 1987).

Castor is gaining importance, as castor oil is used as an economic substitute to other petroleum products. At Dharwad, Groundnut + Castor intercropping at 3:1 row proportion offered significantly higher gross rreturns (Rs. 14,053/ha) which was 18% higher than sole groundnut (Rs. 11,893/ha) with LER of 1.26 (AICRPO, 1987). Groundnut + Castor intercropping system at 5:1 or 7:1 ratio was found suitable under Andhra Pradesh conditions. Similar results were reported by Hegde and Reddy,, (1987).

11.2. Groundnut with pulses:

Groundnut + redgram intercropping is extensively adopted in peninsular India on red sandy loam soils. At Dharwad, Hulihalli and Sheelvantar, (1989) found that intercropping of groundnut and redgram in 5:1 ratio with 100% groundnut: redgram population gave highest total pod:seed yield (2.6 t/ha compared to pure stand of groundnut (1.55 t/ha) and redgram (1.62 t/ha). Intercropping of groundnut and pigeonpea in 5:1 ratio was most remunerative at Anantapur (AICRPDA, 1978, 1979), while 7:1 ratio was more profitable in red sandy loam soils of Tirupati. At Coimba-

tore, intercropping of redgram in 1.50 or 2.25m rows apart in irrigated groundnut grown at a spacing of 22.5cm and 15cm has no significant adverse effect on groundnut yield. The intercrop gave additional yield and increased net returns (Ashokraj *et al.*, 1987). Similarly 3:1 ratio groundnut + redgram intercropping system gave additional redgram yield of 5.37 q/ha without affecting groundnut yield at Rahuri (Sindhe, *et al.*, 1990). Similarly Appadurai and Selvaraj (1974) Veerswamy *et al* (1974) Verma and Srivastava (1987) and Reddy *et al.* (1989) reported that, groundnut redgram intercropping at 3:1 and 6:1 ratio gave higher returns than groundnut or redgram sole cropping. Experiments at five *alfisol* locations at ICRISAT showed that, groundnut:redgram (5:1) intercropping system can produce 82% of sole groundnut and 85% of sole redgram yields, with 67% yield advantage over sole crops (ICRISAT, 1987).

Groundnut intercropping with cowpea or blackgram at a ratio of 3:1 had significantly reduced the incidence of pest, and gave higher benefit: cost ratio than pure groundnut (Logiswaran and Mohan Sundaram, 1985).

11.3. Groundnut with cereal crops

The most important cereal intercrops grown with groundnut are bajra, jowar and maize.

Experiments conducted at Bailhongal in Karnataka indicates that, growing of groundnut:hybrid jowar in 2:2 row proportion gave the highest pod yield of 880 kg/ha and 1312 kg/ha jowar grain yield. At ICRISAT, Groundnut:Sorghum showed an yield advantage of 38% (Rao and Willey, 1980). Lingegouda *et al* (1972) reported that 3 rows of grounut + one row of sorghum was most profitable (Rs. 3918/ha) than sole sorghum (Rs. 3123/ha) or groundnut (Rs. 2672/ha).

Maize + groundnut intercropping system has offered significantly higher net returns (Rs. 6778/ha) over sole crops (Singh and Sharma, 1987).

Intercropping of groundnut and pearl millet in 3:1 row proportion have given greater benefits (Reddy and Willey, 1980). However, Choudhary *et al* (1985) reported that groundnut : pearlmillet (fodder) at 1:1 gave higher monetary returns. Similarly, groundnut yield did not differ significantly in groundnut + pearl millet intercropping system (Bheemaiah and Anand Reddy, 1987).

11.4. Groundnut with commercial crops

Groundnut + Cotton intercropping system (Channal, 1983), paired row planting (45/90cm) or alternate row planting, groundnut yields were on par (1501 and 1547 kg/ha respectively); but seed cotton yield was significantly higher in paired row planting (1128 kg/ha) as compared to alternate row planting (874 kg/ha). At Dharwad, Groundnut: Cotton at 3:1 row proportion gave the highest net returns (Rs. 8487/ha) and gross returns were highest (Rs. 10,071/ha) in paired row planting of cotton (AICRPO, 1980).

Similarly Mathur *et al.* (1977) observed that groundnut + cotton inter cropping was superior to pure crops of cotton and groundnut.

At Dharwad, intercropping of groundnut : chilli at 3:1 row ratio has given significantly higher net returns (Rs. 8487/ha) as compared to sole groundnut (Rs. 4920/ha) (AICRPO, 1980).

Experiments conducted under irrigation in summer at Bhavanisagar and Coimbatore indicated that, raising of groundnut in paired row system with one row of onion in the interspace of 25cm between paired rows of groundnut gave the highest net returns than raising sole crop, and groundnut yield was not affected in intercropping system (UNIAS, 1978).

In Kerala, groundnut: Cassava intercropping is in practice. Cassava in pure stand yielded 10.37 t/ha and when intercropped with groundnut the yield was 10.86 t/ha in addition to 1.86 t/ha pod yield of groundnut. Farmers in Kerala are getting on an average 1236 kg/ha of groundnut yield in addition to Cassava yield (Potti and Thomas, 1978).

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OUTPUT GROWTH STABILITY OF OILSEEDS IN KARNATAKA

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ABSTRACT

The growth in production of oilseeds in Karnataka has remained almost stagnant. However, the variation in total oilseeds production was found to be higher during post-green revolution period (1970-71 to 1987-88) as compared to that of pre-green revolution period (1955-56 to 1965-66). This has been largely contributed by changes in area-yield covariance, changes in mean area and yield variance and the interaction effect between them. A similar trend was observed both in groundnut and other oilseed crops. Hence, policies to be framed for the stabilisation of output of oilseeds in the State, may be directed towards reducing the variability in area-sown and yield variation directly as well as through its related components.

Key words Instability; Growth rate, Coefficient of variation, Variance.

INTRODUCTION

The growth performance of oilseeds has been disappointing as compared to the technological improvements, during sixties, and the resultant impressive increase in productivity of crops like wheat and paddy. Despite its favourable impact on productivity and production, new technology has brought in considerable amount of instability in output, income and employment. In our country, major portion of output is used for direct consumption which is more or less unalterable. Hence, the impact of output instability is more pronounced on the marketed surplus. A bumper crop leads to wide-spread fluctuations in output prices which adversely affects the welfare of rural as well as urban population. This calls for inclusion of output stabilisation, especially that of oilseeds, as an important goal in the national agricultural policy.

The oilseeds production in Karnataka has registered a meagre increase of about 1.8 per cent per annum, in terms of compound growth rate during the last two decades. But this has been accompanied by variability in output which is higher than that of the national average. So, promotion of output stabilization policies are of even greater importance in Karnataka. To appreciate the need for introduction, to a certain degree of stability into the oilseed economy of Karnataka, it is essential to properly analyse and understand the causes of their output instability. This is the primary reason for undertaking the present study.

Here, an attempt is made to understand the components of production which have contributed to the variation in average production of oilseeds over two time periods, viz., pre and post green revolution periods. The specific objectives of the study were to:

1) analyse the trends in the stability of oilseeds in the state.

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2) evaluate the relative importance of and changes in different sources of production instability; and

3) explain the causes for changes in the influence of different sources of production instability.

MATERIALS AND METHODS

The available time series data on production, area and yield of oilseeds for Karnataka state were collected for the period from 1955-56 to 1987-88 from various issues of 'Agricultural Situation in India', a Government of India publication and 'Agriculture in Karnataka - Facts and Figures', published (1987) by Karnataka State Department of Agriculture.

The new crop production technology was introduced in Karnataka duriing the mid-sixties. Hence, the period from 1970-71 to 1987-88 in which the modern technology bore the fruits of green revolution was termed as post-green revolution period (period II). For comparison, the period from 1955-56 to 1965-66 was treated as pre-green revolution period (period I). As per the objectives stated earlier, analysis was done under three heads viz., groundnut which occupies more than 50 per cent, both in terms of area and production of the total oilseed crops in the state, Other crops including all others like - sunflower, safflower, sesamum, niger etc., and total oilseeds comprising both groundnut and other oilseed crops.

The changes in the growth of production, area and productivity of oilseeds after the introduction of new crop production technology were analysed to study the trends in their production and productivity. For this purpose, compound growth rates were worked out by employing different functional forms of the type: linear, log linear, exponential and power functions by taking time as independent variables and values of area, production and productivity during periods I and II as dependent variables. However, in this study, exponential function of the form: $Y=AB$ was finally selected as this was found to be the best fit among different estimated functional forms in terms of significance of the estimated coefficient and high coefficient of determination.

To examine the sources of production variation and corresponding instability, if any, the relevant methodology was built upon the lines of work by Mehra (1981) and Hazell (1982).

Instability was measured as the changes in average production and variance of production of oilseeds of the State. The decomposition of changes in production E (P), between I and II periods into constituent parts which can be attributed separately to changes in means, variances and covariances of area and yield, was done as follows:

Average production in the period I was:

$$E(P_1) = \overline{A}_1 \overline{Y}_1 + CoV.(A_1 Y_1) \quad \ldots \quad \ldots \quad (1)$$

and in the period - II it was:

$$E(P_2) = \overline{A}_2\overline{Y}_2 + CoV.(A_2Y_2) \quad \ldots \quad \ldots \quad (2)$$

Using expressions (1) and (2), the final equation (3), for estimating the changes in average production, E (P); was derived (for details see Hazell; 1982).

$$\Delta E(P) = E(P_2) - E(P_1)$$

$$= \overline{A}_1 \Delta \overline{Y} + \overline{Y}_1 \Delta \overline{A} + \Delta\overline{A} \Delta \overline{Y} + \Delta CoV(A.Y) \quad \ldots \quad (3)$$

This can be explained in terms of its constituent components as given below:

There are four sources of changes in E(P). The first two parts, $\overline{A}_1 \Delta \overline{Y}$ and $\overline{Y}_1 \Delta \overline{A}$ arise from the changes in mean yield and mean area which can be called as 'pure effect'. The term $\Delta \overline{A} \Delta \overline{Y}$ indicates an interaction effect which arises from simultaneous occurrence of change in mean area and mean yield. The last term Δ CoV (AY) arises from changes in variability of area and yield.

The variance of production of a particular period is expressed as:

$$V(P) = \overline{A}^2 V(Y^2) + \overline{Y}^2 V(A_2) + 2\overline{A}\overline{Y} CoV(AY) - CoV(AY)^2 + R \quad \ldots \quad (4)$$

where, $\overline{A}$ = *average area*; $\overline{Y}$ = *average yield*; *and* R = *residual term.*

The change in variance of production $\Delta V(P)$ can be partitioned as done in case of average production. Taking the variance of production, then, applying Goodmann's (1960) expression for the co-variance of the production of two random variables and then applying to the equation (4) leads to the decomposition (for details see Hazell, 1982). These equations are given in Table 4 alongwith the results.

RESULTS AND DISCUSSION

As a prelude to the analysis of components of growth and stability in oilseed production, an examination of growth rates and changes in area, production and productivity of oilseeds between the two periods, as well as inter-period variation in production was attempted and the results are presented in Table 1 and 2.

TABLE 1. Growth rates of area, production and yield of oilseeds in Karnataka during Period-I and Period-II.

(In percentage)

Crops	Area		Production		Yield	
	Period-I	Period-II	Period-I	Period-II	Period-I	FPeriod-II
Groundnut	-0.2073	0.1388	-3.1274	1.8099	-2.4105	1.9747
Other oilseeds	-2.2141	3.6310	-1.9095	5.4008	0.3456	1.7136
Total oilseeds	-0.7430	1.3579	-3.0059	2.5880	-2.2846	0.9873

TABLE 2. Changes in average area, production and yield between Period-I and II of oilseeds in Karnataka.

(In percentage)

Particulars	Groundnut	Other oilseeds	Total oilseeds
Changes in			
Average area	2.95	55.80	16.81
Average production	18.04	155.38	31.71
Average yield	18.25	53.97	15.79
Changes in S.D.			
Area	127.44	516.22	240.00
Production	56.01	1251.52	96.33
Yield	46.63	356.07	11.24
Changes in C.V.			
Production	32.14	429.02	48.11
Yield	24.02	196.08	-3.93

Totally ten sources of change in production variances are identified. The components 1,2,5 and 6 are in concurrence with the sources of change in average production, while the remaining six components represent the effect of interaction between these variables.

Growth rates of area, production and yield

A comparison of growth rates of production, area and yield of total oilseeds during period-II, the growth rates were positive, compared to negative growth rates observed during period-I (Table 1). The growth rate of productivity of total oilseeds improved to 9.09 per cent during period-II due to diffusion of new technology while it was negative (-2.28%) during period-I. Thus, leading to an increase in the growth rate of production (2-59%) in post-green revolution period from a negative growth rate (-3.01%) observed during pre-green revolution period.

A perusal of growth pattern of groundnut revealed that, after green revolution, productivity (1.97%), and area (0.14%) have increased marginally leading to an increase of 1.81 per cent in production from a negative growth rate (-3.13%) observed during period-I.

With respect to other oilseeds, the production has increased to 5.40 per cent from a negative growth rate of -1.91 per cent. Therefore, it is evident from the present analysis that, both productivity and area have jointly contributed for the increase in production. A marginal increase in the production of groundnut (1.81 per cent) coupled with a substantial increase in the production of other oilseeds (5.40 per cent) lead to an overall increase in the total oilseeds production in Karnataka.

Change in production, area and yield:

The average production of total oilseeds in the state increased from 6.37 lakh tonnes in period-I to 8.39 lakh tonnes in period-II (Table 2), accounting for about 31.71 peer cent increase. This increase has mainly been contributed by the increase in the other oilseeds (155.38 per cent), compared to that of groundnut (18.04%), a major oilseed crop. Similarly, the increase in area (16.81%) and productivity (15.79%) of oilseeds is mainly contributed by the larger increase in other oilseed crops (54-56%).

The increase in average production was however, accompained by an increase in instability of output. This is evident from both standard deviation and coefficient of variation of total oilseeds production (S.D : 96.33 per cent and C.V : 48.11 per cent). The degree of instability is much higher in case of other oilseeds (S.D : 1-51 per cent and C.V: *429 per cent*) than that of groundnut (S.D : 56 per cent and C.V : 32 per cent). But this increase is particularly more than proportionate to change in average production in all the categories.

Taking all these into consideration, a detailed analysis of the sources of change in average production and its variability was undertaken to assess and evaluate their contribution to total change in production and its variance over time.

Components of change in average production:

As revealed by Table 3, the increase in average production in total oilseeds, as well as groundnut and other oilseed crops during period-II over period-I is mainly contributed by positive change in area (45.90%) and productivity (43.09 per cent) in total oilseed production. Similar trend was observed in other oilseed crops. However, in case of groundnut, change in average production is mainly contributed by change in productivity (79.72%). In contrast, the interaction effect of changes in mean area

TABLE 3. Components of change in average production between period-I and II

(In percentage)

Sources of change		Groundnut	Other oilseed crops	Total oilseed crops
Description	Components of change			
1. Mean yield	$\overline{A_1} \triangle \overline{Y}$	79.72	35.12	43.09
2. Mean area	$\overline{Y_1} \triangle \overline{A}$	12.89	36.31	45.90
3. Interaction between mean area and mean yield	$\triangle \overline{Y} \triangle \overline{A}$	2.35	19.60	7.24
4. Area-yield covariance	$\triangle C_o V (AY)$	5.04	8.97	3.77

TABLE 4. Components of change in variance of oilseed production in Karnataka.

(In percentage)

Description	Sources of change: Symbols	Components of change	Groundnut	Other oilseed crops	Total oilseeds
1. Change in mean yield	$\triangle\bar{Y}$	$2\bar{A}_1\triangle\bar{Y}\ CoV\ (A_1Y_1)+(2\bar{Y}_1\triangle\bar{Y}+(\triangle\bar{Y})^2)V(A_1)$	1.69	0.33	1.55
2. Change in mean area	$\triangle\bar{A}$	$2\bar{Y}_1\triangle\bar{A}\ CoV(A_1Y)_1+[(2\bar{A}_1\wedge\bar{A}+(\triangle\bar{A})^2]\ V(Y_1)$	1.94	0.79	10.33
3. Change in yield variance	$\triangle V(Y)$	$(\bar{A}_1)^2\ \triangle V(Y)$	37.71	12.60	7.41
4. Change in area variance	$\triangle V(A)$	$\bar{Y}_1)^2\ \triangle V(A)$	11.40	13.68	24.08
5. Interaction between changes in mean yield and mean area	$\wedge\bar{Y}\wedge\bar{A}$	$2\wedge\bar{Y}\triangle\bar{A}\ CoV\ (Y_1A_1)$	0.02	-0.04	0.14
6. Change in area-yield covariance	$\triangle CoV\ (AY)$	$(2\bar{A}_1\bar{Y}_1-2CoV(Y^2A_1)\ \triangle CoV(YA)-(\wedge CoV\ (YA^2)$	33.17	14.37	33.64
7. Interaction between changes in mean area and yied variance.	$\wedge\bar{A}\triangle V(Y)$	$[(2\bar{A}_1\wedge\bar{A}+(\triangle\bar{A})^2]\triangle V(Y)$	2.26	17.98	2.70
8. Interaction between change in mean yield and area variance.	$\triangle\bar{Y}\wedge V(A)$	$[(2\bar{Y}_1\wedge\bar{Y}+(\wedge\bar{Y}))]^2\triangle V(A)$	4.54	18.75	8.20
9. Interaction between change in mean area and yield and change in area - yield co-variance.	$\triangle\bar{A}\triangle\bar{Y}\triangle CoV\ (AY)$	$[(2\bar{Y}_1\triangle\bar{A}+2_1\bar{A}\triangle\bar{Y}+2\triangle\bar{A}]\wedge\bar{Y}\wedge CoV\ (YA)$	7.27	21.54	11.95
10. Change in residual	$\triangle R$	$\wedge V\ (AY)$ - sum of other components	0.00	0.00	0.00

and yield have contributed less to the total change in average production between two periods in all the categories.

Components of change in production variability

The change in area-yield covariance (33.64%) accounted for the largest share in the variance of total oilseed production (Table 4) followed by change in area variance (24.08%). In case of groundnut, the change in yield-variance (37.71%) formed the major component followed by change in area yield covariance (33.17%) and change in area variance (11.40%) to the total variance of production. The interaction components (about 58%) have contributed to a larger extent in the variation of other oilseed production. However, area-yield covariance (14.37%), change in area variance (13.68%) and yield variance (12.60%) have also played their role in the production variability of other oilseeds.

Thus, it can be inferred that the change in area-yield covariance, change in area and yield variances and interaction between them have substantially explained the variation in oilseed production.

CONCLUSIONS

Some of the tenative empiricial conclusions emerging out from this study and possible policy options are summarised below:

1. Production of oilseeds has remained almost stagnant.
2. To reduce production instability, wide fluctuations in the crop area sown has to be reduced.
3. Assured, adequate and timely supply of various inputs, essentially quality seeds from reliable sources.
4. Emphasis may be given on non-traditional oilseeds like soybean.
5. Proper storage facilities and better trade policies, which would ensure fair deal to farmers.
6. A shift in focus of research from supply responses to demand responses.
7. In view of the wider objective of growth in production, some compromise between stability and growth may have to be accepted.

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SEED DORMANCY IN ERECT BUNCH GENOTYPES OF GROUNDNUT (*ARACHIS HYPOGAEA* L.) I. VARIABILITY FOR INTENSITY AND DURATION

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ABSTRACT

A total of 32 erect bunch cultures of groundnut were evaluated for intensity and duration of dormancy over seasons. The cultures D.E.R., ICGS 30, ICG 11498 and ICG 11493 exhibited high intensity of dormancy over seasons while wide fluctuations were evident in ICGS 11, ICG 118 and ICG 11495, when measured in terms of days taken for attainment of 50 per cent germination the cultures Dh 8, D.E.R., ICGS 30 and ICGS 57 showed more than 3 weeks of dormancy. A period of 2-3 weeks of dormancy was exhibited by ICG 11499, ICG 11493, ICG 118, ICG 11497 and ICG 6910 while, a wide fluctuation was evident in ICG 11495, ICG 9489, ICGS 21 and CGC 7. Occurrence of fresh seed dormancy was evident in some of the released non-dormant varieties.

The two subspecies of cultivated groundnut (*Arachis hypogaea* L.) differ significantly in the intensity and duration of seed dormancy after harvest. The cultivars of ssp. *fastigiata* generally lack seed dormancy while those of ssp. *hypogaea* are characterized by long periods of resting period (Krapovickas, 1968) The erect bunch cultivars of ssp. *fastigiata* are popular wherever the growing conditions are short because of their early maturity and easy harvesting. A short period of 2-3 weeks of dormancy in these cultivars would be advantageous to avoid pod loss due to *in situ* germination. Although virginia runner types of ssp. *hypogaea* form a good source of dormancy, chances of recovering dormant recombinings with all the desirable traits of erect bunch type are extremely less (Wadia *et al.*, 1987), The presence of genetic variability for dormancy within ssp. *fastigiata* has been indicated by Hull (1937). Varisai Muhammad and Dorairaj (1968). Pandya and Patel (1986 and Wadia *et al.*, (1987).

But these studies involved limited number of genotypes. Therefore a systematic attempt has been made in the present study to know the extent of variability for dormancy in a large number of erect bunch genotypes over seasons.

Key words Seed dormancy; Variabilty; Groundnut; Genotypes

MATERIAL AND METHODS

The study consisted of three stages of assessment of erect bunch genotypes for seed dormancy. A total of 15 cultures were included in the preliminary survey during summer, 1988. They comprised all the bunch varieties selected for cultivation in Karnataka state, a well known early maturing nondormant culture, Chico beisdes, five erect bunch cultures (CGC 7, Dh 8, ICGS 30 and ICGS 57) that were reported to be dormant (Pandya and Patel, 1986) along with Dharwad Early Runner (D.E.R.), an early maturing dormant culture with sequential branching and flowering on mainstem but trailing in habit (Gowda et al., 1989). In the second stage of evaluation, an additional 17 germplasm lines that were identified to be dormant Genetic Resources Unit (GRU) of ICRISAT were included during Kharif 1989. As a confirmatory study, 11 selected dormant cultures from earlier evaluations were assessed for dormancy along with a nondormant check, Dh 3-30.

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The cultures were harvested at maturity as indicated by blackening of inner surface of the shell, the pods were dried in partial shade for five days and shelled just before germination test. Only sound mature kernels were used for germination test which was initiated at seven days after harvest and there after repeated at weekly intervals. Three replicate samples of 25 seeds each were kept for germination in petriplates lined with filter paper and water was added to a depth of 2mm after moistening the filter paper. The petriplates were incubated at 27±3°C and germination counts were made after 5 days.

The dormancy in groundnut lacks definite periodicity and is a feature of the individual kernel rather than of the whole plant because of asynchronous pod development and maturity. Hence, there is a need to adopt an appropriate methodology to assess relative dormancy among genotypes. In the present investigation, two parameters viz., intensity and duration of dormancy among the cultures and across seasons. The intensity of dormancy was measured as percentage of nongerminated seeds at 7 days after harvest and the duration of dormancy was measured by days taken by a culture to attain 50 per cent germination (G 50). Data on germination percentage after angular transformation was subjected for statistical analysis. The G 50 was estimated by probit analysis (Wardlaw, 1985).

RESULTS AND DISCUSSION

The results of the investigation during summer 1987 are presented in Table 1. When the cultures showing less than 50 per cent germination at first test were considered as dormant, released varieties, TMV 2, Spanish improved, S 206, KRG 1, Dh 3-30, JL 24 and J 11 along with Chico were found to be nondormant (Table 1). Besides the six cultures that were earlier reported to be dormant, a released variety ICGS 11 also showed very low percentage of germination, thus indicating dormancy. The results of study on 32 cultures during second season revealed interesting facts (Table 2). The released nondormant cultures except JL 24 and Spanish Improved showed relatively low germination as compared to the first season but attained more than 90 per cent germination after two weeks of harvest. This kind of response of non dormant cultures is often termed as fresh seed dormancy. The reason for such a behaviour could be inadequate curing resulting in retention of moisture thus blocking oxygen diffusion (Sree Ramulu and Rao, 1968). The eight (ICG 11494, ICG 4108, ICG 4581, ICG 1930, ICG 1133, ICG 4876, ICG 9490 and ICG 1221) of the 15 germplasm lines that were identified as dormant by GRU of ICRISAT however, showed very high per cent of germination at first week and attained more than 90 per cent germination at second week after harvest. Besides, the six cultures that were confirmed as dormant during first season, the remaining nine germplasm lines also recorded very low germination per cent even at two weeks after harvest. All the selected 11 dormant cultures considered for confirmation during summer, 1989 showed very low germination per cent against 90 per cent by the nondormant checks Dh 3-30 in the first week after harvest, thus confirming their true dormant nature. Thus the study revealed 16 cultures viz., Dh 8, CGC 7, ICGS 30, ICGS 57, D.E.R., ICGS 21 ICGS 11, ICG 1499, ICG 11501, ICG 11495, ICG 11498, ICG 11493, ICG 9489, ICG 11497, ICG 6810 to be dormant.

TABLE 1. Germination percentage of groundnut cultures at weekly intervals after harvest (Summer 1988)

Cultures	Germination per cent					
	Days after harvest					
	7	14	21	28	35	42
TMV 2	81	97	100	100	100	100
Dh 3-30	97	100	100	100	100	100
JL 24	99	100	100	100	100	100
KRG 1	79	93	100	100	100	100
S 206	95	100	100	100	100	100
Spanish Improved	95	100	100	100	100	100
ICGS 11	27	79	89	100	100	100
Chico	99	100	100	100	100	100
D.E.R.	04	05	12	23	27	44
CGC 7	13	15	19	27	31	55
Dh 8	31	33	38	45	57	83
ICGS 21	19	39	89	95	100	100
ICGS 30	13	13	19	55	71	93
ICGS 57	27	45	47	51	67	91
J 11	83	89	97	100	100	100
Mean	57.3	67.3	74.0	79.6	83.4	90.9
S.Em. ±	3.50	1.82	1.72	0.90	0.82	0.92
C.D. at 5%	7.16	3.72	3.52	1.85	1.67	1 89

When the intensity of dormancy is considered over seasons the cultures, D.E.R., ICGS 30, ICG 11498 and ICG 11493 exhibited very high values (>90 per cent) in at least two seasons. While, the cultures, ICGS 11, ICG 118 and ICG 11495 fluctuated widely over seasons. The variation for dormancy in terms of duration (G 50) was substantially large as compared to the intensity of dormancy among the 16 dormant cultures. Such variations in the period of dormancy in groundnut has been ascribed to seasonal fluctuations in the environmental factors that affect dormancy by their influence on mother plant and seeds during postharvest storage (John *et al.*, 1948; Bailey *et al.*, 1958; MC Farland and Smith, 1966). The cultures Dh 8, D.E.R., ICGS 30 and ICGS 57 showed more than 3 weeks of dormancy while a period of 2-3 weeks of dormancy was exhibited by ICG 11499, ICG 11501, ICG 11493, ICG 118, ICG 11497 and ICG 6810. A wide fluctuation was evident for G 50 in ICG 11495, ICG 9489, ICGS 21 and CGC 7. The variety ICGS 11 exhibited weak dormancy with G 50 of 11.2±0.2 and 8.0±0.1 in summer, 1988 and kharif 1989, respectively.

TABLE 2. Germination percentage of groundnut cultures of weekly intervals after harvest (Kharif 1988)

Culture	Germination per cent					
	Days after harvest					
	7	14	21	28	35	42
TMV 2	60	95	100	100	100	100
Dh 3-30	60	99	99	100	100	100
JL 24	91	97	100	99	100	100
KRG 1	49	97	99	100	100	100
S 206	65	99	99	100	100	100
Spanish Improved	77	81	97	100	98	100
ICGS 11	37	98	100	99	99	100
Chico	95	100	100	100	100	100
D.E.R.	05	21	43	47	67	99
CGC 7	21	39	45	49	93	99
Dh 8	09	27	39	68	73	92
ICGS 21	03	29	49	85	99	100
ICGS 30	02	11	33	37	97	100
ICGS 57	04	35	41	97	99	100
J 11	37	95	100	100	99	100
ICG 11499	11	13	65	99	99	100
ICG 11501	00	15	65	100	100	100
ICG 11495	08	29	37	69	75	96
ICG 11497	11	47	61	97	100	100
ICG 11498	07	47	47	85	97	100
ICG 11494	96	100	99	100	100	100
ICG 11493	04	55	55	71	99	100
ICG 6810	11	45	64	97	95	99
ICG 4108	96	99	99	100	100	100
ICG 118	45	49	61	71	77	96
ICG 4581	96	99	99	100	100	100
ICG 9489	27	49	75	99	99	100
ICG 1930	81	95	93	100	100	100
ICG 1133	99	99	99	100	100	100
ICG 4876	76	83	99	100	100	100
ICG 9490	67	99	99	99	100	100
ICG 1221	96	99	100	100	100	100
Mean	45.2	66.9	76.9	89.6	95.7	99.4
S.Em. ±	3.1	3.6	3.2	2.9	4.6	2.5
C.D. at 5%	6.2	7.1	6.3	5.8	9.1	4.9

TABLE 3. Germination percentage of selected groundnut cultures at weekly intervals after harvest (Summer 1989).

Cultures	Germination per cent					
	Days after harvest					
	7	14	21	28	35	42
ICGS 30	03	27	27	41	67	85
CGC7	27	64	60	60	89	97
Dh 8	17	40	50	59	85	87
ICGS 57	28	35	49	55	69	93
ICG 11499	13	59	67	97	100	100
ICG 11501	13	63	63	99	100	100
ICG 11498	09	68	68	96	97	100
ICG 11493	09	63	65	65	77	93
ICG 118	11	84	89	91	90	97
ICG 9489	05	49	51	57	63	87
ICG 11495	47	91	91	97	100	100
Dh 3-30	99	100	100	100	100	100
Mean	23.5	61.8	64.9	76.4	86.4	94.8
S.Em. ±	5.1	4.9	4.6	3.5	3.1	5.5
C.D. at 5%	10.6	10.1	9.4	7.2	6.4	11.4

TABLE 4. **Intensity and duration of seed dormancy observed in selected dormant cultures during three seasons.**

Cultures	Intensity of dormancy (%)			Duration of dormancy (G50)		
	Summer 1988	Kharif 1989	Summer 1989	Summer 1988	Kharif 1988	Summer 1989
CGC 7	87	79	73	42.0±0.32	28.0±0.42	16.8±0.24
Dh 8	69	91	83	33.2±0.14	24.5±0.23	21.7±0.35
ICGS 30	87	97	97	28.7±0.33	35.5±0.17	29.4±0.50
ICGS 57	73	96	72	24.5±0.36	21.7±0.18	22.0±0.40
ICGS 21	81	97	—	14.5±0.18	21.2±0.15	—
ICGS 11	73	63	—	11.2±0.02	08.0±0.10	—
D.E.R.	96	95	—	43.0±0.21	28.1±0.19	—
ICG 11499	—	89	87	—	17.5±0.14	15.7±0.19
ICG 11501	—	100	87	—	17.5±0.07	15.7±0.20
ICG 11495	—	92	53	—	24.5±0.21	07.5±0.70
ICG 11498	—	93	91	—	19.2±0.17	17.5±0.16
ICG 11493	—	96	91	—	19.2±0.16	19.9±0.15
ICG 118	—	55	91	—	14.0±0.40	12.2±0.16
ICG 9489	—	73	95	—	14.0±0.21	24.5±0.94
ICG 11497	—	89	—	—	16.4±0.17	24.5±0.94
ICG 6810	—	89	—	—	15.7±0.16	—

G 50 : Days taken for 50 per cent germination.

The stable sources of dormancy identified in the present study are being used in the development of productive, dormant bunch cultivars of groundnut.

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MUTAGEN INDUCED POLYGENIC VARIABILITY IN SOME MUSTARD (*BRASSICA JUNCEA* L.) VARIETIES AND THEIR HYBRIDS.

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ABSTRACT

Dry seeds of two mustard genotypes RCU 101, Domo-4 and their F_1 hybrid were treated with 0.5, 0.75 and 1.0 per cent concentration of EMS and 80, 100 and 120 KR doses of gamma rays. Mean values increased in all traits in most of the treated populations. The enhancement was more evident in EMS treatments. Changes in mean values were followed by increased variance in most of induced populations. Induced variabilty in mutagen treated populations of parents was greater than the induced populations of hybrid F_2M_2. Thus, mutagenesis of F_1 hybrid has no greater advantage for creating variability. The high estimates of genetic variance, heritability and genetic advance revealed that selecion in mutagen treated populations may bring considerable improvement in most of the traits.

Key words: Polygenic variability, *Brassica juncea*, Mutagenesis.

INTRODUCTION

The success of breeding methodology for improving quantitative characters depends primarily on magnitude of genetic variability available and its efficient utilization. The induced mutations have been found quite effective in generating useful variation for polygenically controlled traits (Kumar, 1982). Keeping these objectives in view present investigation was undertaken to induce useful polygenic variability for various traits.

MATERIALS AND METHODS

Preparation of Ethylmethane sulfonate (EMS) treatment

Five millilitres of EMS was dissolved in 100 ml phosphate buffer solution of pH 7 to obtain 0.5 per cent (mol. weight 124.15 gm) concentration. Similarly 7.5 and 10ml of EMS was dissolved in 1000ml at pH 7 solution to obtain 0.75 and 1.00 per cent concentrations, respectively.

Five grams dry seeds of two genotypes RCU 101, from India, and Domo-4 from Canada and their hybrid were pre-soaked in water for two hours with a view to enhance the absorbance of the EMS treatments equally by all the cells in seeds and to activate the endosperm. The seeds were treated with three concentrations 0.5, 0.75 and 1.0 per cent of EMS for twelve hours in 100ml solution each and 80, 100 and 120 kR doses of gamma rays. The doses were selected based on study of Nagamani *et al.*, (1981). The M_1 generation was raised by sowing the treated seeds of each variety and their F_1 hybrid with various doses in 5 rows of 6 meter for each treatment. The plants in M_1 generation of 0.75 and 1.0 per cent EMS treatment in both parents and 1.0 per cent treatment of hybrid (M_1F_1) could not survive up to maturity. M_1 plants were

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bagged to avoid outcrossing and M_2 seed was harvested only from M_1 bagged plants. This seed was used to raise M_2 populations in randomized block design with three repeats. Data was recorded on 15 plants per treatment per repeat for seed yield, 1000-seed weight, primary and secondary branches during 1987-88. The analysis was done with respect to mean, variance, genetic variation, genetic coefficient of variation, heretability and genetic advance.

RESULTS AND DISCUSSION

Table 1 revealed that there were frequent changes in means of mutagen treated populations as compared to control populations. When compared with control, the EMS treated M_2 populations of both genotypes and their hybrid revealed the increase in mean values for all the traits except seed yield; but the enhancement in EMS treatments was particularly high. All irradiation treatments caused significant or slight enhancement of 1000-seed weight, primary and secondary branches in parents whereas in hybrid the increase in mean was comparatively low. There was substantial shift of means in the negative direction in Domo-4 and in hybrid in all treatments for seed weight. The negative shifts in mean values could be attributed to occurrence of deletrious or harmful mutations (Ram *et al.*, 1987). Following the mutagenic treatment, it was observed that various traits were frequently affected in parents than in the hybrid. Further, the direction of shift in means varied with genotypes, mutagen, concentration/dose and character.

The changes in mean in the mutagen treated populations was followed by changes in variance for all characters. In genotype RCU 101, all mutagenic treatments for all traits resulted in increased variance. Similar trend was observed in genotype Domo-4 for all traits except 1000-seed weight in which all treatments resulted in decreased variability. In the hybrid (M_2F_2), the EMS treated populations showed slightly increased variability over the F_2 population (control) for all traits except seed yield. The increase of variability for primary and secondary branches was also evident in the irradiated populations. The F_2 variability (M_2F_2) was greater than that of untreated parents for most of traits, revealing that hybridization between RCU 101 and Domo-4 generated considerable variability. The studies of Sangwan (1972) in Indian mustard have also demonstrated that variation induced in M_2 generation was dependent on variety, mutagen dose or concentration and character under study. This could be attributed to differential sensitivity of genes among genotypes for same trait and within genotype for different characters.

In a careful comparison of the F_2 population and mutagen treated populations of hybrid, it was evident that mutagen could successfully be used to induce variability to supplement the one created through hybridization. However, the critical comparison of the mutagen treated populations of parent and hybrid revealed that there was no evidence that mutagen treatments resulted in greater amount of variation in the parental populations than hybrid populations (Table 2). Obviously, mutagenesis of F_1 hybrid has no greater advantage than the mutagenesis of parents. Similar findings were reported by Emery and Wynne (1976).

TABLE 1. Mean and variances for yield and its component traits in M_2 population.

Genotype/hybrid/ treatment		*Seed yield per plant* Mean	Variance	*Primary branches per plant* Mean	Variance	*Secondary branches per plant* Mean	Variance	*1000-seed weight* Mean	Variance
RCU 101									
Control		9.1±0.23	20.1	5.5±0.02	1.9	9.5±0.02	20.3	2.9±0.08	1.15
EMS	0.5%	11.2±0.32**	36.8	5.9±0.10**	3.6	13.31±0.40**	59.3	3.1±0.04**	2.75
gamma rays	80 kR	8.8±0.29	31.1	5.5±0.09	3.0	9.8±0.27	27.0	3.1±0.06**	5.33
	100 kR	10.7±0.30**	31.9	5.8±0.09**	3.2	11.0±0.36**	47.3	3.0±0.04**	5.33
	120 kR	9.1±2.5	22.9	5.8±0.09**	3.0	10.1±0.29	28.2	3.3±0.06**	5.35
Domo-4									
Control		5.3±0.13	6.5	7.6±0.10	4.1	13.3±0.27	26.3	1.6±0.02	0.05
EMS	0.52	3.3±0.13**	7.0	8.2±0.14**	7.1	14.3±0.32**	37.0	1.8±0.02**	0.05
gamma rays	80 kR	3.7±0.13**	6.6	8.3±0.14**	7.7	17.0±0.33**	38.8	1.9±0.02**	0.04
	100 kR	3.7±0.14**	7.1	8.1±0.16**	9.3	15.7±0.38**	53.4	1.9±0.02**	0.04
	120 kR	4.1±0.15**	8.2	10.0±0.15**	8.7	19.7±0.48**	83.9	1.8±0.01**	0.02
RCU 101 × *Domo-4*									
F_2 Control		8.2±0.25	20.3	7.5±0.12	5.3	13.1±0.35	39.4	1.9±0.04	0.16
EMS	0.52	8.1±0.24	21.1	7.3±0.13	6.9	15.4±0.42	63.6	1.8±0.04	0.18
	0.75%	8.0±0.23	19.9	7.9±0.07*	8.6	15.8±0.33	40.5	1.8±0.05	0.26
gamma rays	80 kR	8.1±0.23	19.2	7.6±0.12	6.0	15.6±0.30	32.1	2.0±0.04	0.16
	100 kR	6.5±0.22	17.5	6.7±0.10**	4.4	13.2±0.30**	32.5	1.9±0.03	0.12
	120 kR	8.0±0.23	19.6	7.3±0.10	4.0	15.1±0.33	45.6	1.9±0.03	0.08

TABLE 2. Genetic variances (GV) genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance (GA) in induced populations (M2).

Genotypic/Hybrid/		Seed yield per plant				Primary branches per plant				Secondary branches per plant				1000-seed weight			
		GV	GCV	h^2	GA	GV	GCV	h^2	GA	GV	GCV	h2	GA	GV	GCV	h^2	GA
RCU 101																	
EMS	0.5%	16.7	36.6	45.4	50.7	0.67	13.7	11.7	7.3	36.2	45.2	60.8	72.5	0.18	13.9	78.2	25.3
gamma rays	80 kR	11.0	37.9	35.4	46.5	0.01	1.3	0.1	10.8	3.7	49.5	13.6	14.8	0.22	15.3	81.4	28.5
	100 kR	11.9	32.5	37.1	40.6	0.23	8.2	8.1	4.4	24.0	44.5	50.7	65.2	0.22	15.6	81.4	28.5
	120 kR	2.9	18.6	12.4	13.4	0.07	4.4	2.1	1.3	4.8	20.2	17.1	17.2	0.17	12.7	77.2	23.0
Domo-4																	
EMS	0.5%	0.5	21.6	7.2	12.0	4.13	24.8	58.0	38.0	13.7	25.9	29.9	32.4	0.02	7.8	40.0	9.9
gamma rays	80 kR	—	—	—	—	4.75	26.1	61.4	42.0	15.5	23.1	39.8	56.2	0.01	5.3	23.0	5.4
	100 kR	0.6	20.2	7.9	11.7	6.88	31.0	67.8	52.6	30.0	34.9	56.2	53.9	0.01	5.3	25.0	5.4
	120 kR	1.6	31.1	19.6	28.1	5.67	23.8	65.5	39.6	60.6	39.6	72.2	69 2	—	—	—	—
RCU 101 × *Domo-4*																	
F_2 Control		6.8	31.8	33.7	68.7	2.35	20.4	44.1	27.8	16.0	27.3	40.7	35.9	0.11	17.5	68.7	29.9
EMS	0.5%	7.8	32.0	39.8	72.2	3.96	25.5	57.1	39.4	40.3	41.2	63.3	67.4	0.13	19.7	72.2	34.1
	0.75%	6.3	31.2	36.0	80.7	5.65	30.3	65.5	50.4	17.2	26.3	42.4	34.9	0.21	24.5	80.7	45.3
gamma rays	80 kR	5.9	29.9	34.2	68.7	2.49	22.9	50.1	33.3	8.7	19.0	27.2	20.4	0.11	16.6	68.7	28.9
	100 kR	4.3	31.8	32.1	58.1	1.38	17.5	31.1	20.2	9.1	22.9	28.1	25.6	0.07	14.2	58.3	22.6
	120 kR	6.3	31.2	35.1	37.5	1.03	14.3	25.6	14.5	22.3	31.3	48.5	45.0	0.03	8.0	37.5	37.5

–negative estimates

The magnitude of induced genetic variability tended to vary from character to character at the same level of dose/concentration of mutagen within each plant. Notably RCU 101 showed greater amount of induced genetic variability for seed yield and 1000-seed weight. The induced genetic variability was however, greater in Domo-4 for primary and secondary branches. A critical examination of the result suggested that EMS treatment resulted in higher genetic component of variation than irradiation. Siddiq *et al.*, (1973) reported that low heritable variation induced by irradiation might be the result of predominantly cryptic chromosomal changes or other induced events of non-fixable nature. EMS on the other hand, seems to induce a high frequency of gene mutations.

Although genetic coefficient of variation is useful to compare the extent of genetic variability for different characters and populations, it is not possible to determine the heritable proportion of variation of a given trait. Broad sense heritability, therefore, was computed to determine the induced genetic effects which may be passed on to the next generations. The high heritability for the quantitative traits enables the plant breeder to base his selection on the phenotypic performance of a trait for its improvement. In the present study low to high estimates of heritability (Table 2) were noted in the progenies of the populations of parents and hybrids. Usually high estimates of heritability were accompanied with high genetic variability and high genetic advance in most of the treated populations Clearly the EMS and gamma rays generated additional variability for improvement of many traits. Similarly Sangwan (1972) found in Indian mustard that estimates of heritability and genetic advance in physical and chemical treated populations were high for many quantitative traits. In another study in Indian mustard, Labana *et al.*, (1980) observed high heritability and genetic advance for population. Thus, based on the results of present investigations and earlier findings, it is concluded that substantial genetic progress could be achieved through mass selection in M_2 populations of mustard.

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PERFORMANCE EVALUATION OF MINI-40 SCREW PRESS (OIL EXPELLER) WITH SOYBEAN (*GLYCINE MAX*)

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ABSTRACT

Mini-40 screw press (oil expeller) was evaluated for its performance with the soybean. It was found that the press did not yield oil with soybean without treatment. The pre-treatments and the moisture content influenced the oil recovery a great deal. Boiling of whole soybean as well as soy split dal, free of hulls in water for 30 minutes followed by drying to about 7% m.c. on pressing yielded the maximum oil recovery of 84.72 and 83.26% with specific energy consumption of 0.503 and 0.370 k Wh/kg of feed, respectively. The capacity of the press was found to be 3.77 kg/h with treated whole soybean and 3.15 kg/ha with treated split dal, free of hulls. The cost of pressing one kg of soybean excluding other unit operations worked out to be Rs. 1.26 and 1.45 corresponding to these treatments in order. Considering the nutritional importance and sale value of deoiled soy cake, boiling soy split dal, free of hulls in water for 30 min. followed by drying to about 7% m.c. (wb) is recommended for oil expression. Capacity of the press being so low, restricts the press,to be recommended for the use under Indian conditions.

Key words. Mini-40 screw press; Soybean; Hydrothermal treatment; Oil recovery; Capacity; Cost economics.

INTRODUCTION

Majority of population lives in the villages where most of the oilseeds are grown. Due to lack of suitable technology and equipment growers sale their oilseeds to the millers located in the urban areas mostly through middlemen at relatively lower prices. The products after milling are received by them at higher costs. Suitable technology and equipment need to be provided to avoid such a situation. This may solve the problem a great deal. Though in India there are many low capacity oil expellers but some how they have not made dents on the requirements of villages. Therefore, a low capacity Mini-40 screw press (oil expeller) which was mainly designed for village industry and on farm application was imported from United Kingdom through the IDRC Canada for adaption in the Indian conditions. It was considered appropriate to evaluate this expeller (Singh and Bargale, 1988) for its performance with different oilseeds under Indian conditions prior to recommending it for use. One of such oilseeds was the soybean which has been identified as a doubly advantageous crop for reducing the demand and supply gap of edible oils in the country. Present article describes the performance and cost economics of the mini-40 screw press (oil expeller) with soybean

MATERIALS AND METHODS

The Expeller

The Rosedown mini-40 screw press (oil expeller) was imported from UK through the IDRC, Canada under the Post Harvest Technology Scheme of Indian Council of Agricultural Research . It mainly consists of the worm shaft and operating screw

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assembly barrel and choke assembly, main frame and drive assembly apart from the feed hopper and safety covers (Fig 1). It is driven by an electric-mootor (3 hp, 3 ph and 940 rpm). The motor rpm has been reduced by the manufacturers to 120 in two steps; one through V-belt pulley arrangement and second through the chain-sprocket for screw-operation. The reported capacity of the press (operator's manual) is 40 kg/h for soft seeds and 90 kg/h for hard oilseeds.

Preparation of Raw Material

The soybean (JS-7244) was taken from the Institute's farm for purpose of evaluation of the press. It was cleaned of its impurities like trashes, chaffs, dust and earthen pieces employing the paddle-cum-power operated seed cleaner (Kachru *et al.*, 1986). The cleaned soybean was dehulled to convert it into split dals free of hulls using CIAE manual dehuller (Singh and Sinha, 1989) because use of raw whole soybean posed problems like power production and severe choking during the expeller operation. Like raw whole soybean, raw soysplit dals also did not give useful result Therefore, prior to feeding further into the oil expeller soysplits as well as whole soybean were given different hydrothermal treatments as follows:

i) Water sprinkling, mixing and conditioning (48h storage in air tight condition for equilibration) to 8.20, 10.60, 13.10, 15, 17.2 and 19.3% m.c. (wb)

ii) Water soaking for 60 minutes followed by sundrying to about 5,7,9 and 11% m.c. (wb)

iii) Boiling of whole soybean for 30 minutes followed by sundrying to about 5,7,9 and 11% m.c. (wb) and

iv) Boiling of soysplits for 30 minutes followed by sundrying to about 5,7,9 and 11% m.c. (wb).

In case of second, third and fourth pre-treatments the duration was decided based on the preliminary investigations.

Operation

The prepared samples each weighing about 5 kg were fed into the operating expeller. During the process, rise in barrel temperature, energy consumption, and time of expression were recorded with the help of digital temperature indicator (make-Naina), energy meter (3 phase, 30 amp, 50 cps and 60 rev/k wh) and stop watch (least count 0.1 second). Number of passes required ranged from 3 to 5 in different cases. All the experiments were replicated thrice. The oil and cake were collected at their respective outlets. The quantity of oil expressed was measured with measuring cylinders and per cent oil left in cake by standard soxhlet apparatus. The oil obtained was allowed to settle for the particles in suspension for about 24 hrs.

TABLE 1. Summary of results on evaluation of Mini-40 Screw press (oil expeller) with soybean (JS-7244).

Sl. No	Treatments prior to expelling	M.C. of* prepared samples (% wb)	Oil recovery (total oil basis) (%)	Passes required (Nos.)	Range of barrel temperature (°C)	Specific energy consumption (k wh/kg of feed)	Capacity** of the press, corresponding maxm oil recovery (kg/h)	Cost of Processing (C1)	Cost of Processing (C2)
1.	Moisture conditioning through water sprinkling	8.20	54.67	5	69.10–143.50	0.593			
		10.60	58.45	5	74.53–133.20	0.531			
		13.10	60.52	5	72.50–129.10	0.522			
		15.00	63.00	5	91.03–123.55	0.413			
		17.20	66.68	5	56.00–103.33	0.403	2.50	1.76	15.52
		19.30	55.17	5	53.00– 95.36	0.542			
2.	Water soaking for 1 h followed by sundrying	5.50	48.35	4	101.00.125.00	0.615			
		7.00	53.54	4	110.00–126.00	0.594			
		9.00	77.50	4	108.4–123.80	0.536	2.50	1.76	12.16
		11.00	62.13	4	110.0–130.00	0.490			
3.	Boiling of whole soybean for 3o min followed by Sundrying	5.00	79.72	3	110.67–133.33	0.545			
		7 00	84.72	3	112.33–125.00	0.503	3.77	1.26	10.23
		9.00	84.04	3	113.33–128.33	0.486			
		11.00	82.55	3	115.67–133.67	0.398			
4.	Boiling of soysplits for 30 min followed by sun-drying	5.00	66.96	4	117.33–140.00	0.445			
		7.00	83.26	3	117.67–135.67	0.370	3.15	1.45	10.76
		9.00	73.34	3	120.00–133.33	0.441			
		11.00	66.65	4	113.33–135.00	0.444			

* The moisture contents have been rounded off to nearest full digits.

** Capacity of the press in this study has been defiined as the quantity of soybean crushed for per hour in order to get maximum oil recovered in the total number of passes.

C^1 Cost of pressing one kg soybean through mini-40 screw press (oil expeller) corresponding to the condition which gave maximum oil recovery, excluding other unit operations

C^2 Total cost of processing corresponding to the conditions which gave maximum oil recovery, to obtain one kg of oil including all other unit operations viz., cost of cleaning, pre-treatments and pressing through mini-40 screw press (oil expeller) but excluding cost of the raw material.

TABLE 2. Detailed cost-analysis for **processing one kg of soybean for expression of oil using mini-40 screw press with different pre-treatments at optimised moisture parameters**

Operating parameters

Cost of the mini-40 screw press (oil expeller) - **Rs. 10.00**
Life of the press - 5 years
Operation hours per day - 16
Days of operation per year = 300

Sl. No.	Parameters	PRE-TREATMENTS			
		Moisture conditioning through water sprinkling	1 h tap water soaking followed by sundrying	30 min. boiling of whole soybean followed by sundrying	30 min. boiling of soy-splits followed by sundrying
1	2	3	4	5	6
1.	Capacity of the press at different pre-treatment, kg of feed/h	2.5	2.5	3.77	3.15
2.	Oil recovery (% moisture free total oil basis)	66.70	77.50	84.72	83.30
3.	Energy consumption (k wh/kg of feed)	0.54	0.53	0.50	0.37
4.	Optimised moisture contents (% wb)	17.2	9.0	7.0	7.0
5.	*Cost of cleaning per kg of soybean, (CIAE pedal operated cleaner) Rs.	0.02	0.02	0.02	0.02
6.	*Cost of dehulling per kg of soybean (CIAE power operated soybean dehuller) Rs.	0.04	0.04	N.A.	0.04
7.	*Cost of pre-treatment per kg of feed, (CIAE soybena blancher) Rs.	N.A.	N.A	N.A.	0.26

Contd.

8.	Cost of pressing one kg of feed in mini-40 screw press.				
	(A) *Fixed costs*				
	(i) Depreciation, Re.	**0.13**	0.13	0.09	0.10
	(ii) Interest @ 18%, Re.	**0.09**	0.09	0.06	0.07
	(iii) Housing and Insurance, @ 10%, Re.	**0.08**	0.08	0.05	0.06
	Total fixed costs	**0.30**	0.30	0.20	0.23
	(B) *Variable costs*				
	(i) Two operators/day (@ Rs. 20/day) Re.	**1.00**	1.00	0.66	0.79
	(ii) Energy consumption (Re. 0.50/k Wh) Re.	**0.30**	0.30	0.29	0.30
	(iii) Repair and maintenance @ 20% per year	**0.16**	0.16	0.11	0.13
	Total variable costs	**1.46**	1.46	1.06	1.22
	Cost of pressing in mini-40 screw press, (A+B), Rs. per kg oilseed	1.76	1.76	1.26	1.45
9.	Total cost of processing one kg of soybean for oil expression using above unit operations (5 + 6 + 7 + 8)	**1.82**	1.82	1.54	1.77
10.	Total cost of processing to obtain one kg of oil using above unit operations, Rs.	15.52	12.16	10.23	**10.76**

* References : Anon. (1988) and Kachru *et al.*, (1987).

RESULTS AND DISCUSSION

Results on evaluation of Mini-40 screw press (oil expeller) with soybean have been presented in Table 1. No encouraging results were obtained with raw samples as such they have not been included in the table. On comparison it could be seen that per cent oil recovery was maximum (about 85%) in case of pre-treatment of whole soybean boiled in water for 30 minutes followed by sundrying to about 7% (wb) moisture content with energy consumption of about 0.486 kWh/kg of feed. Also the cost of pressing one kg of soybean excluding other unit operations was found to be Rs. 1.26 while cost of processing to obtain one kg of oil including all other unit operations viz., cost of cleaning, pre-treatments and pressing through Mini-40 screw press worked out to be Rs 10.23. Details of the cost analysis corresponding to the best result conditions is given in Table 2. In case of soysplits (free of hulls) boiled in water for 30 minutes followed by sundrying to about 7% m.c. the maximum oil recovery was found to be 83% with energy consumption of 0.370 kWh/kg of feed. The cost of pressing one kg of soybean excluding other unit operations was Rs. 1.45 and the total cost of processing to obtain one kg of oil including all other unit operations mentioned above worked out to be Rs. 10.76. These are slightly more when compared to previous treatment. Results of other two treatments, namely water sprinkling and 1h water soaking followed by drying presented in Table 1, indicate that apart from relatively lower oil recovery, the energy consumption as well as the cost of processing were more.

Results presented in Table 1 also reveal that per cent oil recovery is influenced both by the treatments as well as the miosture content of the finally prepared samples. In general it can be seen that as moisture content of the samples increased the per cent oil recovery also increased. But beyond certain limit of the moisture as is seen from Table 1, it decreased. Wet heat treatment helped in getting the maximum oil recovery. It could be due to the fact that faster penetration of wet heat coagulates the protein, making the oil cell-walls more permeable in relatively less time. On compression, the cell-walls burst quickly releasing the oil. In case of whole soybeans presence of hulls during the compression probably helped generating more frictional forces making compression more effective. These hulls also provide relatively better porous media for easy oozing out of the oil. But the fact remains that presence of hulls in the cake adversely affects the quality, making the cake unsuitable for edible purposes. Therefore, considering the nutritional importance and the sale value of cake the boiling of split dal free of hulls may be appreciated for oil expression.

However, results also reveal the fact that the press capacity was very poor in almost all the cases. This could be so due to limitations for increasing the feeding, more number of passes required to be given and the problems of choking etc. The capacity reported in the Table 1 corresponds only to the cases wherein maximum oil recovery was obtained. The energy consumption was also found to be on higher side making the process costly.

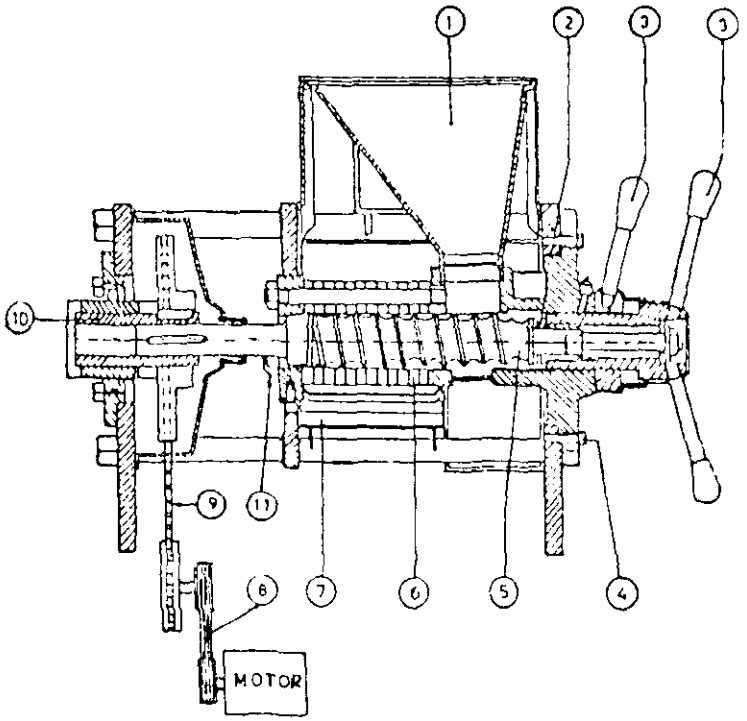

FIG 1 : SECTIONAL VIEW OF MINI-40 SCREW PRESS (OIL EXPELLER)

CONCLUSIONS

i) The screw press did not yield oil with raw samples of whole soybean or split soydal.

ii) Considering a combination of factors pre-treatment of 30 min water and boiling of soysplits free of hulls followed by drying to about 7% moisture content is recommended for oil expression purpose.

iii) The capacity and the cost-economics of the mini-40 screw press restrict from recommending the press for oil expression under Indian conditions.

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NITROGEN HARVEST INDEX IN RELATION TO PRODUCTIVITY IN GROUNDNUT (*ARACHIS HYPOGAEA* L.)

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ABSTRACT

Twelve lines derived from three single crosses were used to evaluate the role of the two characters, nitrogen harvest index (NHI) and total nitrogen percentage (TN) in selection or producivity in groundnut (*Arachis hypogaea* L). The selected lines could be differentiated either by the breeding process, intermating or selfing, through which they were evolved or by their high or low yield levels. There was significant variation among the lines for TN and NHI. NHI was positively and significantly correlated with pod yield. NHI and TN together could identify the yield status of all the lines correctly. The mean values of NHI and TN were much higher in high yielding lines compared to the values of their superior progenitor parent. The reverse was true for low yielding lines. The results suggest that nitrogen harvest index is an important parameter to reckon with in programmes of yield improvement in groundnut.

Key words: *Arachis hypogaea*; Nitrogen harvest index; Yield; Nitrogen content.

INTRODUCTION

Parameters relevant to nitrogen fixation are particularly important in programmes aiming at improving productivity of self-pollinated legumes like groundnut (*Arachis hypoguea* L.). Nitrogenase activity is one such parameter and is usually taken to be a direct measure of nitrogen fixation.

As estimated *in situ* acetylene reduction technique, it is vitiated by a number of variable factors like soil moisture incubation temperature, diurnal variation and light intensity (Nambiar and Dart, 1983). Total available nitrogen (TN) ranks as an alternative since it was reported to have a direct association with nitrogenase activity (Mytton, 1983) and had also high positive correlation with grain yield (Desai and Bhatia, 1978 in durum wheat, Westermann and Kolar, 1978 in common been, Ronis et al., 1985 in soybean), Likewise, nitrogen harvest index (NHI) is another parameter reported to have high positive correlation with yield (Paccaud et al., 1985 in winter wheat, Brunner and Zapata, 1984 in field bean).

It would therefore be of interest to examine the availability of genetic variation for NHI and TN in consciously selected lines of groundnut which were differentiated either by the breeding process through which they were evolved or by their (high or low) yield levels. Using this experimental material, and an attempt is made to evaluate the role of NHI and TN in yield improvement.

MATERIALS AND METHODS

Lines generated from there crosses were used for the study. The crosses had a highly adapted *Virginia* bunch cultivar, Robut 33-1 as female and one of the accessions,

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chico, NC AC 17090 or PI 298115 as male parent. Lines were generated from each cross by one generation of intermating followed by natural self-pollination (IM) or by natural self-pollination alone (SF). From each category, one high (H) and one low (L) yielding line was chosen. The yield was assessed by a joint score across pod yield, shelling percentage and 100-kernel weight following the method of Arunachalam and Bandyopadhyay (1984). A total of 12 lines provided the experimental material (Table 1). They were grown with their 4 progenitor parents and two checks, NFG 3 and NFG 7 in a randomised block design with 4 replications. The plot size was a row of 10m length with plants spaced 10cm and rows 60cm apart. The crop was grown under normal agronomic practices and plant protection measures. 30 kg N and 50 kg P_2O_5 per hectare were applied as basal dressing and 250kg gypsum per hectare at pegging stage. Observations were made on random samples of six plants per plot. Nitrogen per cent was estimated by microkjeldahl method. Plant samples dried to constant temperature were ground to a fine powder; a homogeneous sample of 500mg was used to estimated total N percentage. Total N was calculated as total N% X dry weight of the plant. N percentage in pod walls and kernels was similarly estimated to provide pod N kernel N using which NHI 1 and NHI 2 were computed as follows:

TABLE 1. Material selected for studies on nitrogen harvest index in groundnut.

Cross	Yield potential	Lines	
		IM	SF
Robut 33-1 × Chico	High	(*) RCEH	RCAH
	Low	RCEL	RCAL
Robut 33-1 × NC Ac 17090	High	R9EH	R9AH
	Low	R9EL	R9AL
Robut 33-1 × PI 298115	High	R5EH	R5AH
	Low	R5EL	R5AL

(*)XCodes used in the text.

$$NHI = \frac{\text{Kernel N}}{\text{Pod N}} \times 100$$

$$NHI\ 2 \quad \frac{\text{Total N}}{\text{Pod N}} \times 100$$

In addition, pod yield, shelling percentage and 100-kernel weight were also measured. The yield potential of the lines was judged by a score across the direct yield components, pod yield, shelling percentage and 100-kernel weight, following the method of Arunachalam and Bandyopadhyay (1984). The lines were assigned a performance status-High or Low, based on the scores. The utility of nitrogen harvest index and/or total nitrogen percentage in judging the performance (yield) status was

TABLE 2. ANOVA (mean squares) for various characters in groundnut

Source	d.f.		[a]Total N	[b]Nitrogen harvest index		[a]Pod yield	[b]shelling	[b]100-kernel
	a	b	(g/plant)	1	2	(g/plant)	percentage	weight (g)
Entries	17	17	16245.42*	37.40*	236.60*	15.22*	23.45*	31.47*
Lines	11	11	8763.42	19.90	177.90*	14.38*	12.66	18.85
Parents	3	3	27355.26*	96.55*	511.08*	19.09*	60.56*	73.81*
Checks	1	1	29016.83	37.07	170.24	16.85*	21.58	28.36
Rest	2	2	34845.94*	45.07	180.88*	13.15*	28.08*	38.91*
Error	51	17	8755.26	10.53	42.56	3.01	6.56	9.09

a = Based on 4 replications; b = Based on 2 replications;

TABLE 3. Mean values of various lines for some characters in groundnut.

Progenitor cross	Identity of line	Total nitrogen (g/plant)	Nitrogen harvest index		Pod yield (g/plant)	Shelling percentage	100 kernel weight (g)
			1	2			
Robut 33-1 × Chico	RCAH	448.8b	88.9a	59.8b	4.3ab	67.0a	44.7b
	RCAL	281.3a	89.1a	53.9b	2.9a	65.0a	31.8a
	RCEH	408.5ab	88.8a	53.3b	6.3b	68.1a	51.7c
	RCEL	327.0ab	88.8a	35.1a	4.2ab	65.9a	38.8b
Robut 33-1 × PI 298115	R5AL	430.3a	88.0a	40.5a	6.0a	68.6a	47.4a
	R5EH	459.8a	89.1a	50.3a	6.9a	68.4a	44.1a
	R5EL	457.0a	86.6a	41.3a	5.3a	66.8a	42.7a
Robut 33-1 × NC AC 17090	R9AL	337.3a	83.5a	23.0a	2.5a	65.3a	31.8a
	R9EH	412.0a	89.0a	48.6b	5.2b	68.4a	46.5c
	R9EL	357.3a	87.4a	41.2b	6.6b	65.4a	38.6b
C.D. at 5%		132.8	6.9	13.8	2.5	5.4	6.4

Values carrying the same letters are not significantly different.

TABLE 4. Mean values of IM and SF, High and Low lines for some characters in groundnut

Progenitor cross	Identity	Total nitrogen (g/plant)	Nitrogen harvest index		Pod yield (g/plant)	Sheling percentage	100-kernel weight (g)
			1	2			
Robut 33-1 × Chico	IM	367.8a	88.8a	56.9b	5.3b	67.0	45.2b
	SF	365.0a	89.0a	44.2a	3.6a	66.0a	38.3a
	High	428.6b	88.8a	56.6b	5.3b	67.5a	48.2b
	Low	304.2a	88.9a	44.5a	3.6a	65.4a	35.3a
Robut 33-1 × PI 298115	IM	458.5a	87.8a	45.8a	6.1a	67.2a	43.4a
	SF	415.4a	86.9a	44.5a	5.8a	66.1a	42.1a
	High	443.8a	87.5a	49.4a	6.2a	66.1a	45.0b
	Low	430.1a	87.3a	40.9a	5.7a	67.7a	40.5a
Robut 33-1 × NC Ac 17090	IM	421.1a	88.8b	44.9b	5.9b	66.9a	42.6b
	SF	384.6b	84.0a	31.3a	3.0a	65.4a	38.1a
	High	458.5b	86.1a	44.1b	4.4a	67.0a	45.5b
	Low	347.3a	86.0a	32.1a	4.6a	65.3a	35.2a
C.D. at 5%		93.9	4.8	9.7	1.7	3.8	4.5

Values carryng identical letters are not significantly different.

evaluated by comparing the percentage of lines in which the status assigned by a particular set of characters agreed with the performance status.

The yield status of the 12 lines was assessed in two successive rainy seasons. The status remained stable only for 10 lines (except R5 AH and R9 AH). They were only considered, therefore, for drawing inferences.

RESULTS AND DISCUSSION

There was substantial variation among progenitor parents for all the characters (Table 2). The variation among lines was significant for pod yield, 100-kernel weight and nitrogen harvest index 2. The high variation among parents might be explained by the differences between the adapted cultivar, Robut 33-1, on the one hand and the three male parents which were germplasm accessions with comparatively low, yield performance, on the other.

Differences among lines derived from Robut 33-1 × Chico were observed for TN, NHI 2, pod yield and 100-kernel weight and in those from Robut 33-1 × NC Ac 17090 for the latter three traits. Lines derived from Robut 33-1 × PI 298115 failed to show differences (Table 3). Similar results were also observed, in general between 1M and SF or between High and Low lines derived from the above two crosses (Table 4).

Total nitrogen singly or in combination with nitrogen harvest index 10 could assess the High or Low performance status of all the 10 lines correctly (Table 5). Nitrogen harvest index 2 was only next in priority in the correct identification of yield status. The predictive ability of nitrogen harvest index would partly be explained by its significant correlation with pod yield and shelling percentage (Table 6) among others.

TABLE 5. Efficiency of various character combinations in predicting the yield status of 10 lines.

Character set	Number of lnes in which there was agreement
Total nitrogen	10
Total nitrogen + Nitrogen harvest index 1	10
Nitrogen harvest index 1	8
Total nitrogen + Nitrogen harvest index 2	8
Nitrogen harvest index 2	6

TABLE 6. Significant (at 5% level) correlation coefficients (r) between characters measured in groundnut.

Character combination	r
Pod yield – Nitrogen harvest index 1	0.64
Pod yield – Shelling percentage	0.64
Pod yield – Nitrogen harvest index 2	0.59
Total nitrogen - 100-kernel weight	0.67
Shelling percentage – Nitrogen harvest index 1	0.67
Shelling percentage – Nitrogen harvest index 2	0.54

The direct association of total nitrogen and nitrogen harvest index with pod yield was clearly brought out (Table 7) in their range of values between high and low yielders. Lines with high yield status and values higher than those of the better parent, Robut 33-1 for those characters; similarly lines with low yield status recorded values lower than those of Robut 33-1 (Table 7).

TABLE 7. Maximum and minimum values observed for nitrogen harvest index and total nitrogen in 12 lines and their progenitor parents in groundnut.

Mean Value		Total nitrogen (g/plant)		Nitrogen harvest index			
				1		2	
Maximum		RCAH	449	(*))		RCAH	60
		R5EH	460	R5EH	89	R5EH	50
		R9EH	412	R9EH	89	R9EH	49
Minimum		RCAL	281	(*)		RCEL	35
		R5AL	430	R5EL	87	R5AL	40
		R9AL	337	R9AL	85	R9AL	23
Significant	Robut 33-1 X Chico		+	—		+	
differences	Robut 33-1 × PI 298115		—	—		—	
in populations							
derived from	Robut 33-1 × NC Ac 17090		+	—		—	
Parents	Robut 33-1		477		85		45
	Chico		140		90		59
	PI 298115		426		75		25
	NC Ac 17090		394		77		28

(*) **NHI 1 values** for all the populations derived from **Robut 33-1** × Chico = 89.

Nitrogen accumulation is an important parameter in N metabolism which can be used as a criterion for selection particularly because it is indicative of biological nitrogen fixation (Mytton *et al.*, 1984). Genetic variation for N accumulation has been reported in many crops including groundnut (Williams, 1979). Nitrogen harvest index takes into account both nitrogen percentage and dry matter. It has also been reported to have constently high correlation with seed yield (Jeppson *et al.*, 1978). Nitrogen harvest index is the result of cumulative effects of a number genetically controlled activities and their interaction with environment, a reason why it can be used as an effective criterion of selection (Cregan and Van Berkum, 1984). The result that there was high agreement between yield status of lines and the status given by nitrogen harvest index I and total nitrogen (Table 5) was earlier obtained in other crops as well.

For instance, a re-analysis of the data on soybean from Jeppson *et al.* (1978) could show that the status allotted by total nitrogen per cent agreed with that given by grain yield in 11 and that allotted by nitrogen harvest index in 9 out of 13 genotypes. In a similar re-analysis of data on winter wheat from McNeal *et al* (1968), the status given by total nitrogen agreed in 4 out of 7 genotypes (Radhakrishna, 1986). The low agreement per cent in wheat could be explained by the low relevance of nitrogen fixation in that crop.

Further nitrogen harvest index was found to be correlated with yield and its direct components (Table 6), a result that had also been reported in other crops like soybean (Jeppson *et al.*, 1978) and *Vicia faba* (Brunner and Zapata, 1984). In addition, its correlation with harvest index was also found positive in those reports. That nitrogen harvest index can be stable over years and takes into consideration with nitrogen percentage and dry matter are reasons weighty enough to suggest the use of nitrogen harvest index with advantage in programmes of yield improvement in legumes like groundnut.

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MAINTAINER AND RESTORER BEHAVIOUR OF SOME SUNFLOWER LINES ON NEW CYTOPLASMIC MALE STERILE SOURCES

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ABSTRACT

Two new sources of cytoplasmic male sterility-CMS PF and CMS I - were tested for their maintainer and restorer behaviour. Sixteen B lines and 13 R lines related to classical source-CMS F were crossed to new CMS types. The presence or absence of pollen in F_1s was recorded in the field whereas pollen fertility was confirmed in the laboratory by Acetocarmine staining test. The study revealed that the new sources not only differ from the classical source-CMS F-but also differ each other. Maintainer and restorer lines are reported for the two new sources.

The discovery of cytoplasmic male sterility in sunflower (*Helianthus annuus* L.) by Leclercq(1969) and subsequent identification of genes for fertility restoration (Enns *et. al.*, 1970; Kinman, 1970; Leclercq, 1971 and Vranccanu and Stoenescu, 1971) have resulted in the commercialization of sunflower hybrids using the cytoplasmic genetic male sterility system. To date, almost all sunflower hybrids grown are based on a single source of male sterile cytoplasm - CMS F discovered by Leclercq (1969). Diversification of CMS source is inevitable in any heterosis breeding programme as the use of single CMS source involves a potential risk if it is becoming susceptible to a new strain of disease. Fortunately in sunflower several new sources of cytoplasmic male sterility have been reported (Anaschenke, *et al.*, 1974; Heiser, 1982; Leclercq, 1980; Serieys and Vincourt, 1987; Whelan, 1980 and Whelan 1981).

Two new CMS sources - CMS I and CMS PF are available in our breeding programme. The objective of the present investigation was to establish distinctness of these new sources and identify maintainers and restorers for them by crossing with the known B and R lines of classical cytoplasm-CMS F.

Key words *Helianthus annuus*; cytoplasmic male sterility; maintainers and restorers.

MATERIALS AND METHODS

In order to identify maintainers and restores for new CMS sources sixteen B and thirteen R lines related to CMS F were crossed to CMS *petiolaris follax* (CMS PF) and CMS *indiana* (CMS I). Though a total of 29 lines were crossed to both the cytoplasmic lines, only 24 lines with CMS PF and 21 lines with CMS I gave required number of hybrid seeds. Each test hybrid was grown in a single row of 3.6m with plants spaced at 30cm apart during summer season of 1990 at GKVK, Bangalore. The hybrids were examined for presence or absence of pollen shed. Further, pollen fertility was confirmed using 1 percent Acetocarmine (Chowdary *et al.*, 1981) and the hybrids were grouped as either fertile or sterile. Based upon this data, the B and R lines could be classified as restorers and maintainers for the new cytoplasm.

RESULTS AND DISCUSSION

a) *Fertility Restoration:* Twenty out of 25 lines tested behaved as maintainers for CMS PF and produced sterile hybrids. It was interseting to note that many of

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TABLE 1. Behaviour of B and R lines of CMS Fin the background of CMS PF and CMS I.

Genotype	Cyto sterile background		
	XCMS F	CMS PF	CMS I
$86B_3$	M	M	M*
300	M	M	NT
302	M	M	NT
303	M	M	M*
336	M	M	NT
361	M	R	M*
400	M	M*	R
604	M	M	M*
607	M	NT	M
608	M	NT	R
822	M	M	R
850	M	M	R*
851	M	R	R
852	M	M	M
853	M	M	M*
86LB46	M	M	NT
RR-1	R	M	M
6D-1	R	NT	R
84-SR	R	M	NT
87R 1231/1	R	M	NT
87R 1228/4	R	M	R
272	R	M	NT
273	R	NT	M
274	R	M	NT
278	R	M	M*
296	R	M*	M
299	R	M	M
857	R	M	R
859	R	NT	M

R = Restorers NT = Not tested

M = Maintainers * = Needs confirmation

the restorers of classical CMS F cytoplasm were maintainers of CMS PF cytoplasm. The data further indicated that two maintainer lines of CMS of cytoplasm-361 and 851 carry restorer genes for this CMS PF cytoplasm (Table 1).

For CMS I, seven lines - 400, 608, 822, 851, 6D-1, 87R 1228/4, 837 behaved as restores while the other seven lines - 607, 852, RR-1, 273, 296, 299, 859 behaved as maintainers. From the study it was evident that among the three CMS sources, restorers for CMS PF are rather scarce.

A few crosses showed segregation with one or two fertile/sterile plants in their progeny. This was attributed either to contamination of foreign pollen or the heterozygosity of the lines to restorer genes. However, these crosses will be further evaluated during the next season.

b) *Comparison of CMS PF and CMS I cytoplasm with CMS F:* Using a set of restorers / maintainers of the CMS F it was possible to differentiate the two new CMS sources. Restorer genes efficient on cytoplasm F were ineffective in the other cytoplasmic backgrounds. Based on hybrid behaviour with reference to fertility/sterility the following conclusions could be drawn.

1. CMS PF could be maintained by CMS F restorers viz., RR-1, 84-SR, 87R 1231/1, 87R 1228/4, 272, 274, XX 278, 299 and 857.

2. None of the CMS F restorers restored fertility in CMS PF cytoplasm. However, two maintainers - 361 and 851 of CMS F restored fertility in CMS PF.

3. CMS I could be maintained by CMS F maintainers - 607, 852, as well as CMS F restorers - RR-1, 273, 296, 299, 859.

4. Some of the CMS F maintainers - 400, 608, 822, 851 and restorers - 6D-1, 87R 1228/4 and 857 - restored fertility in CMS I.

From these results it may be concluded that the two cytoplasms are different classical French cytoplasm. Similar observations were also made by Serieys and Vincourt (1987) and Whelan (1981). However, in the present study additional maintainers and restorers have been identified for CMS PF and CMS I sources.

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CARBON TRANSLOCATION ACCOUNTING FOR YIELD VARIATION IN PEANUT (*ARACHIS HYPOGAEA* L.)

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ABSTRACT

Nine lines of peanut (*Arachis hypogaea* L.) including four high yielders, one non-nodulating line and its progenitor parents, one high nitrogen fixer and a national check, were studied *in situ* for 14C translocation to various plant's parts- leaves,stem, root nodule, shell and kernel - at peg development and harvest stages. Of the 68% of observed yield variation accounted for by the carbon translocation to roots, nodules, shells and kernels at harvest, 65% was accounted by the former two traits alone. The relative increase in translocation to roots and nodules at harvest over peg development stage directly influenced pod yields. This was substantiated by the nature and magnitude of correlations between pod yield (PY) and % 14C at peg development (PD) and harvest (HS) stages. There was no correlation between PY and % 14C in (root-l-nodule) at PD; but that correlation at HS was positive and significant. The observed differences in 14C partitioning between the high and low yielders suggest partitioning of carbon to reproductive parts as an additional economic selection criterion for improving productivity in peanuts.

Key words Peanut; Yield potential; Selection; Assimilate partitioning; Carbon translocation.

INTRODUCTION

Among the factors determining pod yield in peanut, partitioning of daily assimilates to the growing fruit is of crucial importance. This inference was arrived at from a physiological analysis of yield differences of popular varieties released in the U.S.A. in the distant and recent past (Duncan *et al.*, 1978). While Dixie runner, one of the earliest varieties with an yield potential of 2.4 t/ha had a partioning factor of 41%, Early Bunch, a variety released in the recent past with an yield potential of 5.4 t/ha had a very high partitioning factor of 99%. Even under conditions limiting net photosynthetic rate, it has been found possible to increase inter-organ partitioning of dry matter from unusable vegetative parts to commercially useful sinks (Gifford *et al.*, 1984). Experimental evidence was wide to support this view (Graham, 1978; Carlson and Brun, 1984; Crafts-Bradner *et al.*, 1984). It will then be feasible to use translocation of assimilates to growing fruit as a selection criterion to improve productivity in peanuts.

At the Indian Agricultural Research Institute, a number of high yielding peanut lines has been derived in the research programme of a national project on peanuts. Four of those lines and a few genetically diverse lines differing in yield were used as the test material to ascertain the extent to which carbon translocation could account for the observed yield differences and wheather it could be a useful selection criterion. The results are reported here.

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MATERIALS AND METHODS

Nine lines of peanut consisting of four developed in a national project (NFG 7, NFG D, NFP 140, 1441-A-1), a non-nodulating line, Non-nod and its progenitor parents, Nc 17 and PI 259747, a national check, Robut 33-1 and a high nitrogen fixing accession from North Carolina, NC Ac 2821 were grown in a randomised block design with three replications. The crop received a basal dressing of 50 kg P_2O_5 and 30kg N (as the available N in the soil was very low at 129 kg/ha) as per the national recommendations. At pegging stage, 250 kg gypsum ($Ca\ So_4$) was added. The crop was grown after the onset of monsoon under recommended cultural practices. The lines were sown in single row plots of 5m length on ridges spaced 60cm and plants within a ridge spaced 10cm apart.

All the lines initiated flowering by 40 days after sowing (DAS). Pegs started developing 90 DAS and the crop reached harvest stage around 120 DAS. The peg development (90 DAS; PD) and harvest (120 DAS; HS) stages were used for measuring carbon translocation to plant parts.

In situ 14_c isotope feeding was employed to measure translocation. The isotope was fed on two plants per plot in the field (which was irrigated two days before sampling) after caging the plants in special polythene chambers measuring 30cm × 30cm × 30cm. Isotope solution in the form of sodium carbonate (28. 25m ci/m mole) was diluted to give 30μ ci/ml. 200mg non-radioactive sodium carbonate and 4ml distilled water were added 1ml isotope solution. $^{14}CO_2$ was released by mixing 8ml of 70% perchloric acid. The whole process had earlier been standardised by the radiotracer unit of the Department of Agricultural Chemistry, Andhra Pradesh Agricultural University, Hyderabad, India.

Each sample was incubated for 40 minutes. 24 hours after isotope feeding, the plants were pulled out and separated into leaves (LF), stem (SM), roots (RT), nodules (ND), shell (SH) and kernel (KL). The samples were dried in a hot air oven. The dried plant parts were separately ground fine and one g dry samples were exposed under a Geiger-Muller Counter (GCS 13) for 200 seconds at 1410 working volts.

The distribution of ^{14}C was estimated taking into account the dry weight of plant parts. For example, Z_i, the % ^{14}C in plant part i was calculated as:

$$Z_i = \frac{W_i X_i}{\sum_{i=1}^{6} W_i X_i} \times 100$$

where w_i was the dry weight and x_i the isotope count of plant part i, i=1,6. i=1 refers to LF, 2 to SM, 3 to RT, 4 to ND, 5 to SH and 6 to KL.

Dry pod yields of the sampled plants were also noted.

RESULTS AND DISCUSSION

There was considerable variation among the 9 lines for dry weight and carbon translocation to plant parts as reflected in their mean values (Table 1). The lines, NFG 7, NFP D, 1441-A-1, Robut 33-1 and NC Ac 2821 gave pod yields per plant above the experimental mean (30.4 g plant^{-1}). In general about 75% of 14_C was translocated to leaf and stem with individual variation among lines. More than 80% of 14_C were found in leaf and stem in the lines NC 17, Non-nod and NFP 140. High % 14_C in the plant organs, root, nodule, shell and kernel, was observed in NFG 7 (31.3%) and Robut 33-1 (25.4%).

TABLE 1 Per cent dry weight (D) and 14C (T) in different plant parts at harvest in peanut.

Line	LF + ST		RT + ND		SH + KL		Pod yield (g/plant)
	D	T	D	T	D	T	
NC Ac 2821	50.4	77.2	2.5	4.6	47.1	18.2	31.9
NFG 7	51.2	68.7	2.4	6.0	46.4	25.3	45.3
NFP D	51.1	76.5	2.4	4.7	46.5	18.8	36.2
NFP 140	53.2	80.5	3.0	3.2	43.8	16.3	24.0
1441-A-1	53.5	67.2	3.0	3.8	43.5	21.0	36.1
NC 17	58.4	83.8	3.1	4.1	38.5	12.1	21.4
PI 259747	60.1	75.3	4.3	2.8	35.6	21.9	19.9
Non-nod	67.9	80.9	3.6	2.1	28.5	17.0	9.5
Robut 33-1	50.3	74.6	2.5	4.3	47.2	21.1	49.2
Mean	55.1	76.1	3.0	4.0	41.9	19.1	30.4
SE ±	5.94	5.48	0.64	1.15	6.46	3.81	8.04

Dry weights were distributed among above ground (leaf+stem) and underground (root+nodule+shell+kernel) organs almost equally (Table 1). Non-nod provided an exception where the dry weight of leaf and stem was about double that of the rest of the organs.

High yielding lines like NFG 7 and Robut 33-1 partitioned relatively high carbon to root, nodule, shell and kernel while the opposite was true of low yielders like NC 17 and Non-nod. In some lines such a direct association was not apparent. For example, carbon patritioned to underground parts was 24.8% for 1441-A-1 with an yield of 36.1 g plant^{-1}. This difference for PI 259747 with an yield of 19.9 g plant^{-1}. This difference was complemented by a higher dry matter accumulation in 1441-A-1 in pod (SH+KL), double that of PI 259747 at harvest. As inferred in grain legumes

like chickpea and pigeonpea, efficient mobilisation of carbon and nitrogen from stem and leaves and high photosynthetic and N-fixing rates during seed filling would also be the other important factors for explaining differences in productivity (Singh, 1990). Maximum C and N fixation occurred during flowering and early fruiting phases in chickpea while about half of the net photosynthate and N were fixed in the vegetative period itself in pigeonpea allowing for better remobilisation to pods at periods of seed fill explaining its comparatively higher yields.

The association between pod yield and 14_C and in various plant parts varied between peg development and harvest stages (Table 2). While none of the correlation coefficients between pod yield and 14_C in (leaf+stem), (root+nodule) or (shell+kernel) was significant at peg development stage, the former two was significant at harvest. In particular, there was a positive and significant correlation between 14_C in (root+nodule) and pod yield at harvest.

TABLE 2. Correlation coefficients (r) between % 14C in various plant parts and pod yield at peg development (PD) and harvest (HS) stages in peanut.

r	PD	HS
PY, C in (LF + ST)	-0.55	-0.67*
PY, C in (RT + ND)	0	0.81*
PY, C in (SH + KL)	0.52	0.60

*Significant at P=0.05

Such an association was lacking between dry weight of plant parts and 14_C in them at both stages (Table 3). The only exception was a negative correlation between dry weight and 14_C of (leaf+stem) at harvest. There was thus no premise *a priori* on which dry weight of plant parts could substitue 14_C in them as selection criteria.

TABLE 3. Correlation coefficients (r) between dry weights and % 14C in various plant parts at peg development (PD) and harvest (HS) stages in peanut.

r	PD	HS
LF + ST	-0.63	-0.75*
RT + ND	0	0.48
SH + KL	0.64	0.47

*Significant at P=0.05

The relative efficiency of several linear regression equations in accounting for the observed variation in pod yield was then compared. Only two equations, numbered 1 and 3 (Table 4), could account, with a single independent variable, for more than

50% of variation in pod yield. Of these two, the linear regression equation between pod yield and % 14_C in (root+nodule) at harvest was the best accounting for 65.5% of variation in pod yield. When 14_C in (shoot+kernel) was also included the coefficient of determination could rise only to 68.4% not justifying their inclusion despite the extra cost and time in measuring them. But the relative increase in 14_C in (root+nodule) at harvest over peg development stage was found to be an important factor in determining pod yield (R^2=54%, Table 4).

TABLE 4. Regression equations of pod yield (Y) on percent 14C (x) partitioned to roots and nodules in peanut.

	Regression equation	R^2
1	$Y = -5.2 + 8.98^* x_1$@	65.5
2	$Y = -38.6 + 1.61^* x_2$@	68.4
3	$Y = 21.2 + 0.17^* x_3$@	54.0

@ x_1 : 14C in (root + nodule) at harvest;

x_2 : 14C in (root + nodule + shell + kernel) at harvest;

x_3 : Relative increase in 14C in (root+nodule) at harvest over peg development stage.

R^2 : *Coefficient of determination*

The results led to two major inferences:

a. Pod yield was a function of partitioned carbon to roots and nodules.

b. The increase in partitioning to roots and nodules from peg development to harvest stages had a substantial influence on realised pod yields.

Evidence to support partitioning of assimilates to reproductive parts as a selection criterion is abundant in published literature. Its use in constructing productive legume plant types had earlier been recognised (Graham, 1978). Where efforts were unsuccessful at increasing the rate of photosynthesis, inter-organ partitioning of photosynthates was used as a successful method to realise commercial sinks (Gifford *et al.*, 1984). Higher rate of photosynthate translocation to developing pods during peak filling period (corresponding to pod development stage of this study) resulted in higher yields of groundnut mutants compared to other derived genotypes (Lodha *et al.*, 1983). In general, at the pod filling stage, a majority of 14_C is required to be translocated to pods as plant parts compete for carbon among themselves for assimilation into specific sinks (Russell and Johnson, 1975). When accumulated carbohydrates in the stem were not remobilised for seed development, poor yield resulted in *Phaseolus* (Adams *et al.*, 1978). Selection of genotypes with more specific sink demands (where leaves translocated most photosynthates to pods) has been practised in soybean (Carlson *et al.*, 1984) and cowpea (Pate *et al.*, 1984). Published evidence suggests the need to select genotypes with

profuse pod formation to generate more sink demand as was done in soybean (Carlson *et al.*, 1984) or that the sink demand itself did not exhaust the available source resulting in the retention of photosynthates in the leaves at late pod filling period (Egli *et al.*, 1980) which limits realisation of the full genotypic potential.

Selection that can be operated before digging of pods saves a lot of time and labour in peanut research. In an earlier study (Prabhu *et al.*, 1990) the utility of leaf area and total nitrogen % measured 30 days after flowering in selecting productive genotypes was highlighted. This investigation adds one more vital selection parameter namely, the rate and extent of carbon translocation to reproductive sinks around harvest.

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POPULATION LEVELS OF *NACOLEIA* SPP. ON SOYBEAN IN RELATION TO WEATHER FACTORS AT MEDIUM ALTITUDE HILLS.

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ABSTRACT

The influence of maximum, minimum temperature, rainfall and accumulated day degree temperature was studied on soybean leaf folder, *Nacoleia* spp., at medium altitude hills in Meghalaya. Both maximum and minimum temperature were found positively correlated while rainfall negatively correlated with the larval population of leaf folder. The accumulated day degree (D°) indicated that the leaf folders appeared at 499.8-900.4D° and their peak at 1072.1-1729.0D°. The plant infestation was recorded to the tune of 46-73% and the number of folds ranged from 1-7/plant. The larvae/fold ranged from 1-3 with a maximum of 5/fold.

Key words: Population levels, *Nacoleia* spp. Day degree, Weather factors.

INTRODUCTION

Soybean (*Glycine max* (L.) is an important leguminous crop and has been recently introduced for its commercial cultivation in Khasi Hills of Meghalaya. The crop is attacked by a large number of insect pests (Gujarati and Gangrade, 1972; Gangrade, 1974; Sarma, 1987 and Devi, 1988). The detailed account of the pest complex on soybean at hills has been given by Sachan and Gangwar (1980). Among these, the soybean leaf folders (*Nacoleia vulgalis* Guen and *N. diemenalis* Guen) are the economic pests and cause yield losses to the tune of 9.2% (Azad Thakur, 1985).

The information on the influence of weather factors on the population levels of *Nacoleia* spp. is not available, hitherto from the medium altitude hills and especially from Khasi hills of Meghalaya. Thus, the present investigations were undertaken in the agro-climatic conditions of high rainfall areas prevailing at medium altitude of Khasi hills in Meghalaya.

MATERIALS AND METHODS

Field experiments were conducted consecutively for 5 years in Kharif from 1983 to 1987, at Barapani (91.56°E, 25.34°N 962m, above mean sea level) Research farm of ICAR Research complex. For the purpose 10 quadrates each of 2×2m containing 100 plants/quadrate were sown with cv. 'Bragg' on May 20, 1983; May 12, 1984; May 7, 1985; June 3, 1986 and May 15, 1987 which were kept free from insecticidal application until the harvest of crop. The larval population as well as number of folds made by them were counted at fortnightly interval on 10 at randomly selected plants/quadrate thus 100 plants were observed at each observation. The weather data (maximum and minimum temperatures, relative humidity and rainfall) were also recorded every year. The age of the crop was also taken into consideration for each year. The larval popu-

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lation was subjected to log (n+1) transformation and then subjected to the (product moment correlation (William, 1940) with physical factors prevailing during the preceeding weeks to establish the influence of these factors on larval population.

The day degree corresponding to pest population was computed by the formula given by Lindsey and Newman (1956).

$$\text{Day Degree } (D^\circ) = \frac{h + m}{2} = t \text{ when } t < m$$

Where h=maximum temperature and t=threshold temperature, and m=Mean temperature.

The threshold temperature of 5°C (No development was possible below 5°C. was taken for calculating the day degree requirement of pests at different time intervals.

RESULTS AND DISCUSSION

During 5 years (1983-1987) of study, it was recorded that the folds made by *Nacoleia* spp. were observed after 15 days of sowing of crop and new folds were observed throughout crop growth period. The population of leaf folder increased gradually and showed distinct peak during August every year synchronizing with stage of crop, (Fig.1) However, the physical factors recorded, fluctuated from year to year. The maximum temperature ranged from 21.7°C to 34.5°C, minimum temperature from 17.1 to 23.8°C, relative humidity from 68. 0 to 93.1% and total rainfall in a year from 921.7mm to 1540.1mm. The average per cent plant infested ranged from 46.0-73.5%. The number of folds/plant ranged from 1 to 7 (Fig. 1) but the maximum load of folds were observed on 16.21 to 23.08% plants. It was also recorded that the number of larvae/fold ranged from 1 to 3 with a maximum of 5 larvae/fold.

Correlation for 5 years from 1983 to 1987 between number of leaf folds and maximum temperature indicated positive trend (r=0.587, 0.602, 0.200, 0.446 and 0.296), positive with minimum temperature (r=0.700, 0.602, 0.882, 0.818) excepting in 1986 (r=—0.059), positively with relative humidity (r=0.652, 0.352, 0.686) excepting in 1986 (r=—0.006) and in 1987 (r=-0.108) and negative trend with rainfall (r=-0.275, -0.038, -0.026 -0.418, -0.423).

It is therefore, inferred that maximum temperature and minimum temperature have definite and positive influence on the number of leaf folder while preceding weeks rainfall has negative effect on the leaf folders. Sarma (1987) and Devi (1988) also reported the same effect of weather factors on *Nacoleia* spp. in Assam on soybean crop.

Infestation of plants:

It is observed that 1 fold on 16.21-33.09% plants, 2 folds on 12.79-24.01% plants, 3 folds on 3.51-11.45% plants, 4 folds on 0·79-5.86% plants, 5 folds on 0.49-4.00%

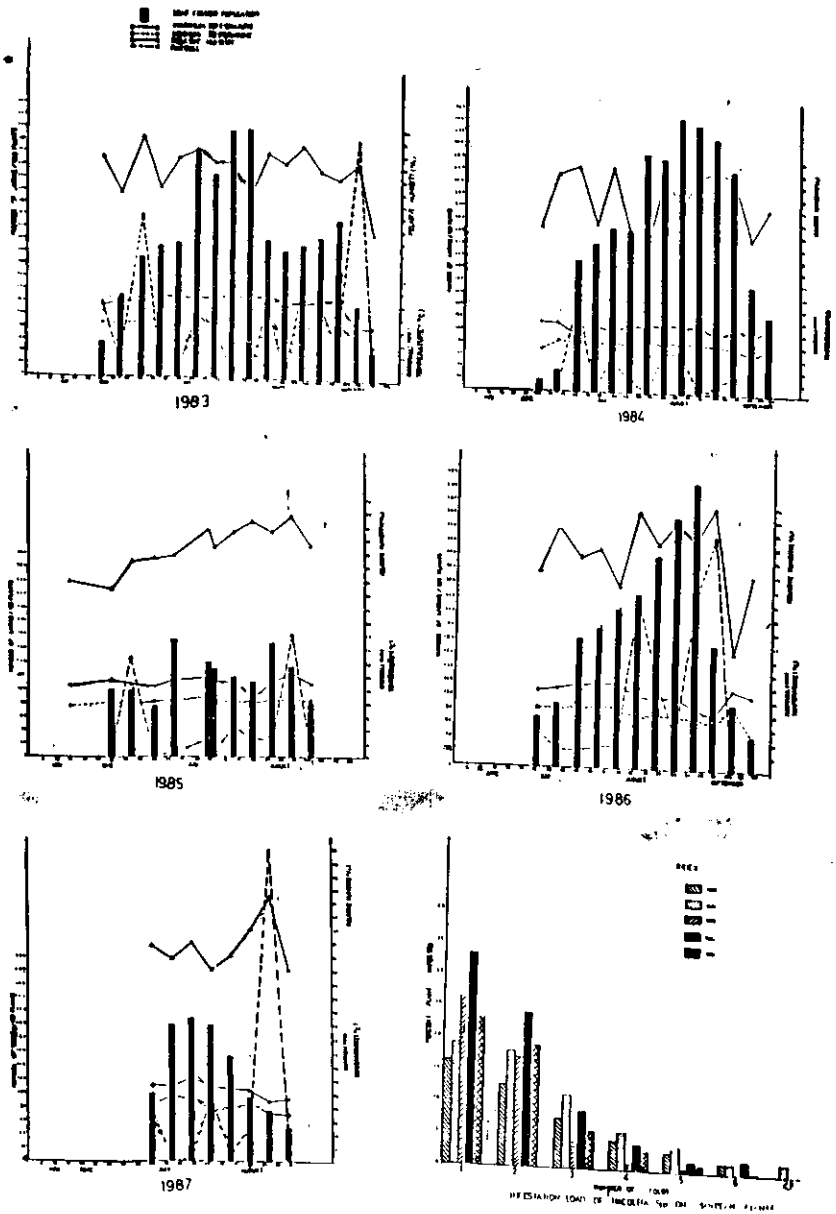

Fig 1 POPULATION DENSITIES OF LARVAE OF NACOLEIA SPP AND CLIMATIC FACTORS

plants, 6 folds on 0.06-1.83% plants and more than 7 folds/plants were observed on 1.67% plants. It is therefore, evident that 1-2 folds/plant were observed abundantly. Sachan and Gangwar (1980) also observed same trend during 1977-78 at 800m elevation (Nayabungalow) in Meghalaya.

Day Degree (D°)

The *Nacoleia* spp. were first recorded at the accumulated day degree of 843.7, 934.3, 499.8 742.4, 900.4 D° and peak at 1576.4, 1511.5, 1072.1, 1440.4, 1729.0 during 1983, 1984, 1985, 1986 and 1987 respectively. The above data of 5 years indicated close resemblance which give support that the prediction of appearance and peak period of activity of *Nacoleia* spp. is possible and can be made use in control operations of the pest in field. Based on the accumulated day degree parameters. The prediction of other pests like *Rhagoletis indifferens* (Aliniazee, 1976), cereal aphid (Ba Angood and Steward, 1980), diamondback moth (Butts and Mc Evan, 1981), *Brevicoryne brassicae* (Kotwal *et al.*, 1985) and cabbage maggot (Eckernrode *et al.*, 1985) have been successfully made paving the way for its successful utilization in control schedule.

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INFLUENCE OF SOWING DATES AND NITROGEN ON THE YIELD OF MUSTARD (*BRASSICA JUNCEA* L.)

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ABSTRACT

The effect of three dates of sowing (30 Oct, 10 Nov. and 20 Nov.) and four levels of nitrogen (0,20,40 and 60 kg/ha) was studied for two consecutive seasons at Regional Agricultural Research station, Tikamgarh M.P. The crop sown on 30 Oct, gave significantly higher yield (8.44 q/ha) as compared to 10 Nov.(6.88 q/ha) and 20 Nov. (5.97 q/ha) sowings. The crop responded to nitrogen application linearly upto 60 kg N/ha. Application of 60 kg/ha nitrogen gave significantly higher yield (11.24 q/ha) than 40 kg N/ha (7.69 q/ha) which in turn was superior to 20 kg N/ha (5.83 q/ha). The highest nitrogen use efficiency, cost benefit ratio and return from additional yield were obtained with 60 kg N/ha.

Key words : Mustard, *Brassica juncea* L; Sowing Dates; Nitrogen application.

INTRODUCTION

In view of the acute shortage of edible oil in the country, efforts are under way to introduce mustard (*Brassica juncea* (L) in Bundelkhand region though the area under rabi oilseeds in this region is negligible. Wheat is the main rabi crop of the region. Mustard can be taken up either as pure rabi crop or as a mixed/intercrop with wheat. The crops other than wheat normally do not receive fertilizer. Studies on the efforts of dates of sowing and nitrogen application on mustard have been made by several workers elsewhere (Jain *et al.*, 1986; Singh and Srivastava, 1986) but information is lacking for Bundelkhand region. Therefore the present investigation was made to study the performance of mustard under varying dates of sowing and levels of nitrogen.

MATERIALS AND METHODS

A field experiment was conducted for two consecutive seasons of 1985 and 1986 at the Regional Agricultural Research Station, Tikamgarh, Madhya Pradesh. The soil of the experimental field was clay loam with pH 7.5, low in available nitrogen (300 kg/ha), medium in available P_2O_5 (20 kg/ha) and high in available K_2O (327 kg/ha). The treatments consisting of three dates of sowing (30 Oct, 10 Nov. and 20 Nov.) and four levels of nitrogen (0, 20, 40 and 60 kg/ha) were tested in a split-plot design replicated four times. A common basal dose of 40 kg P_2O_5 and 30 kg K_2O/ha was applied at the time of sowing. Nitrogen was applied as per treatments, half the dose at the time of sowing and the remaining half at 35 days after sowing. Mustard variety Varuna was sown on a net plot size of 4×2.7m accommodating six rows with inter and intra row spacing of 45×15cm. The crop was irrigated at 35 and 70 days after sowing. The total rainfall received during crop season was 98mm and 17.8mm in 1985 and 1986, respectively.

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RESULTS AND DISCUSSION

Effect of date of sowing

Dates of sowing affected the yield of mustard significantly in both the years. Early sowing on 30 October provided substantially higher yield than the latter dates and any further delay caused a progressive decline in yield, the decrease being 18.39 and 29.28 per cent due to sowing on 10 and 20 November, respectively (Table 1). The increase in yield was due to cumulative effect of growth and yield attributing characters.

TABLE 1. Effect of dates of sowing and Nitrogen on seed yield of Mustard.

Treatments	Seed Yield (q/ha)		
	1985–86	1986–87	Pooled
Sowing date			
30 Oct.	6.90	9.98	8.44
10 Nov.	5.46	8.31	6.88
20 Nov.	4.78	7.16	5.97
S.E. m ±	0.19	0.17	0.21
C.D. 5%	0.58	0.58	0.66
Nitrogen (kg/ha)			
0	2.44	4.02	3.23
20	4.83	6.82	5.82
40	6.37	9.01	7.69
60	9.32	13.17	11.24
S.E. m ±	0.15	0.10	0.29
C.D. 5%	0.48	0.30	0.95

Sowing from 30 October to 10 November resulted in descernible increase in the number of primary and secondary branches over 20 November sowing in 1986; while these growth parameters were uneffected by sowing date in 1985 (Table 3). Similarly the number of siliquae per plant, the number of grains per siliquae, test weight and seed yield per plant was higher in first date of sowing than the later sowings (Table 4). However, the differences in number of siliquae per plant and number of grains per siliquae were not descernible in 1985-86, but the increasing response of these characters contributed substantially to seed yield per plant. There was progressive reduction in all these characters in later dates. In early sowing the reproductive phase was comparatively longer which resulted in higher seed yield. Similar results were reported by Jain *et al.*, (1986) Anonymous (1985) and Shastry and Kumar (1981).

TABLE 3. Effect of date of sowing and nitrogen on growth components of mustard

Treatments	Plant Height (cm.)		Primary branches/plant		Secondary branches/plant	
	1985–86	1986–87	1985–86	1986–87	1985–86	1986–87
Sowing date						
30 Oct.	131.87	173.31	4.13	**5.93**	4.08	9.75
10 Nov.	**129.43**	162.93	3.75	**5.39**	3.53	8.15
20 Nov.	103.87	155.81	3.57	**4.52**	3.33	6.12
S.E. m ±	5.93	1.31	0.192	**0.17**	0.42	0.49
C.D. 5%	20.50	4.54	**NS**	0.59	NS	1.72
Nitrogen (kg/ha) 0 kg/ha	91.08	115.08	**3.11**	**2.77**	2.21	2.65
20 kg/ha	117.50	170.91	**3.66**	4.46	3.10	7.37
40 kg/ha	128.00	176.91	**3.90**	5.73	4.00	9.29
60 kg/ha	149.41	192.33	**4.55**	8.16	5.24	12.70
S.E. m ±	3.26	1.65	**0.276**	0.13	0.41	0.50
C.D. 5%	9.46	4.79	**0.802**	0.40	1.21	1.47

TABLE 4. Effect of sowing dates and nitrogen application on yield attributes

Treatment	Siliquae/plant		Number of grains per siliquae		Seed yield per plant (g)		1000 seed weight (g)	
	1985–86	1986–87	1985–86	1986–87	1985–86	1986–87	1985-86	1986–87
Sowing date								
30 Oct	70.06	199.75	10.56	13.19	6.19	7.47	4.31	4.55
10 Nov	69.56	169.56	10.31	11.88	4.88	6.01	3.78	4.12
20 Nov	59.75	149.93	10.00	10.99	4.11	5.36	3.45	3.79
S.E. m ±	8.67	3.85	0.40	0.14	0.27	0.18	0.07	0.04
C.D. 5%	NS	13.32	NS	0.46	0.94	0.62	0.24	0.17
Nitrogen (kg/ha)								
0 kg/ha	36.91	107.33	8.50	9.46	3.37	2.18	2.94	3.09
20 kg/ha	49.16	146.83	10.40	11.73	4.59	5.32	3.69	4.08
40 kg/ha	75.75	178.00	10.58	12.80	5.59	7.11	4.09	4.53
60 kg/ha	103.33	260.16	11.60	14.10	6.69	9.89	4.67	4.92
S.E. m ±	5.33	9.36	0.27	0.20	0.22	0.20	0.04	0.06
C.D. 5%	15.46	27.17	0.79	0.58	0.64	0.58	0.11	0.16

TABLE 2. Cost benefit ratio and nitrogen use efficiency under different doses of nitrogen application to mustard.

Nitrogen (kg/ha)	Cost of nitrogen (Rs.)	Yield (q/ha)	Additional yield due to nitrogen (q/ha)	N.U.E.* (kg. seed/ kg N)	Return from addl. yield (Rs.)	C.B. ratio
0	—	3.23	—	—	—	—
20	100	5.82	2.59	12.95	1554	15.54
40	200	7.69	4.46	11.15	2676	13.38
60	300	11.24	8.01	13.35	4806	16.02

*N.U.E. = Nitrogen use efficiency

Unit cost of: Nitrogen @ Rs. 5/kg
Mustard @ Rs. 6/kg.

Effect of Nitrogen

Increasing graded nitrogen level from 0 to 60 significantly enhanced the yield of mustard in both the years (Table 1). The per cent increase in yield over control due to application of 20,40 and 60 kg/ha nitrogen was 18.64, 138.31 and 247.10 per cent, respectively. The nitrogen use efficiency (Tabe 2) was 12.95, 11.15 and 13.35 and cost benefit ratio was 15.54, 13.38 and 16.02 under 20,40 and 60 kg/ha, respectively.

Similarly plant height, number of primary and secondary branches per plant, number of siliquae per plant (Table 4, number of grains per siliquae, seed yield per plant and test weight increased with increase in level of nitrogen. The growth and yield attributing characters were responsible for higher yield due to 60kg N/ha. Similar results were obtained by Singh and Srivastava (1986), Anonymous (1985), Singh (1981), and Singh (1981).

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RAPID MULTIPLICATION OF *MELIA AZEDARACH* LINN. THROUGH TISSUE CULTURE

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ABSTRACT

Minor oilseeds of tree origin have great potentials in mitigating the present day oil crisis. Normally, trees take several years to grow and produce seeds. The technique of *in vitro* multiplication of *Melia azedarach* L. plants from nodal explants has been standardized. The present technique is rapid and promising for mass production of large number of superior plants of *Melia azedarach*, for better maintenance of genetic characteristics and also to overcome the problem of seed viability associated with the tree species.

Key words: *Mlia azedarach*; Mass propagation: Tissue culture.

INTRODUCTION

Melia azedarach Linn., a native of West Asia, is a fast growing minor oilseed which has naturalized all over India and in many tropical countries. Seeds of this tree species yield 30 per cent of drying oil which is suitable for industrial uses like making soaps and hair oils. Besides oil, the tree yields a timber tolerant to attack by white ants. This species is also cultivated for its ornamental and shade value on account of its quick growth.

Seeds of *M. azedarach* loose their viability with time (Randhawa, 1983). To overcome this problem and to produce plants throughout the year, tissue culture technique has been applied for mass propagation of this tree species. This technique, earlier used mostly for herbaceous angiosperms (Murashige, 1974) has now been followed for large scale production of some important tree species (Bonga, 1977; Bajaj, 1986; Arya and Shekhawat, 1986; Rao, 1987; Rao and Lee, 1987). The present investigation was therefore undertaken to develop tissue culture protocol for mass propagation of *M. azedarach*.

MATERIALS AND METHODS

Shoot segments approximately of 6 cm length were obtained from one to two years old mature trees of *M.azedarach*. Explants were washed in running tap water for 60 minutes and then rinsed with 0.2% teepol (Shell, India) solution. After washing with distilled water, segments were dipped in 70% ethanol for 30 seconds. Surface sterilization was done with 0.1% (w/v) mercuric chloride solution for 20 minutes followed by thorough washing with sterile glass double distilled water. Segments were separated into one cm pieces each bearing a single node. Nodal explants were cultured on solidified MS medium (Murashige and Skoog, 1962) supplemented with various concentrations and combination of BA (6-benzyl amino purine), KIN (Kinetin) and NAA (Napthalene acetic acid). The pH of the medium was adjusted to 5.8 before solidi-

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fying the medium with 0.8% agar. (Bacteriological grade, Qualigens). All cultures were maintained in a culture room at 26 ± 2 degree centigrade and a relative humidity of 58-60% with 16/8 hour photoperiod. Each treatment consisted of 24 replicates and each experiment was repeated twice.

RESULTS

Nodal segments cultured on MS medium supplemented with low concentration of kinetin (0.5 mg/l) showed growth of callus from the base of the segments and elongation of a single shoot. However, higher concentration of KIN (2.0 mg/l) was unable to induce any response from the explants. BA (0.5 mg/l) incorporated into MS medium induced the elongation and proliferation of the axillary bud accompained by slight callus formation at the base (Table 1). Higher concentration of BA (2.0 mg/l) triggered the induction of few fragile and pale and green shoots from the axillary buds. Combinations of BA (1.0 mg/l) and NAA (0.5 mg/l) did not induce any response in the explants.

TABLE 1. Response of nodal explants of *Melia azedarach* to various phyto hormones.

Medium mg 1	Response
MS + KIN (0.5)	Base starts callusing; axillary bud elongates to fifth node.
MS + BA (0.5)	Base forms dark brown callus; axillary bud elongates and proliferates.
MS + KIN (2.0)	No growth
MS + BA (2.0)	Slight proliferation of axillary bud, plant fragile and pale green in color.
MS + BA (2.0) + NAA (0.5)	No growth

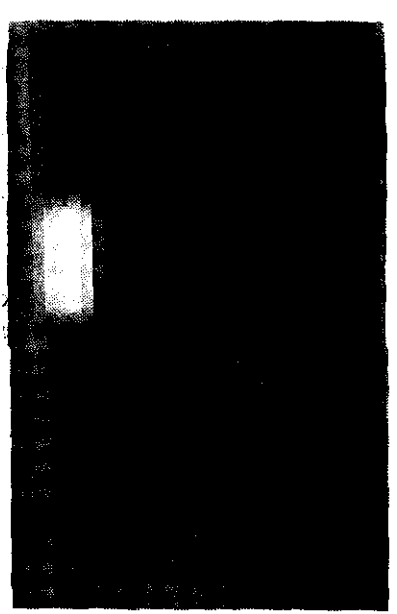
MS = Murashige and Skoog's basal medium.

KIN = Kinetin

BA = 6 - benzylamino purine

NAA = Napthalene acetic acid

BA at 0.5 mg/l was found to be the best for induction of shoot proliferation. Shoot clusters were separated at the base and the callus region was discarded before subculturing to fresh media. Due to the rapid growth rate, subculturing was done at 2 week intervals. Each shoot cluster, at the end of a 2 week culture period, consists of one dominant shoot which is longer (4-6 cm) than the rest surrounded by numerous tiny shoots. Axillaries of 1-3 basal nodes also elongate. Axillary branching alongwith rapid proliferation from the base leads to a higher rate of multiplication which is 10 fold for every two weeks.



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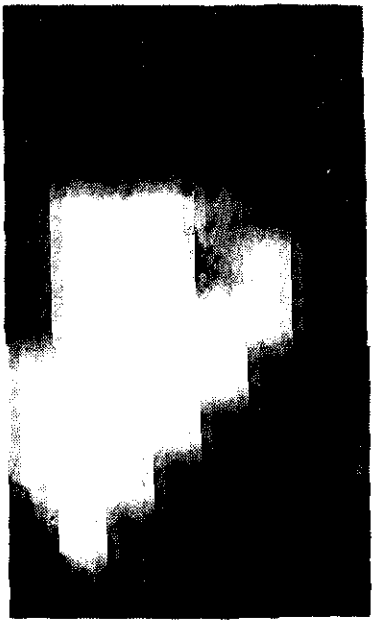

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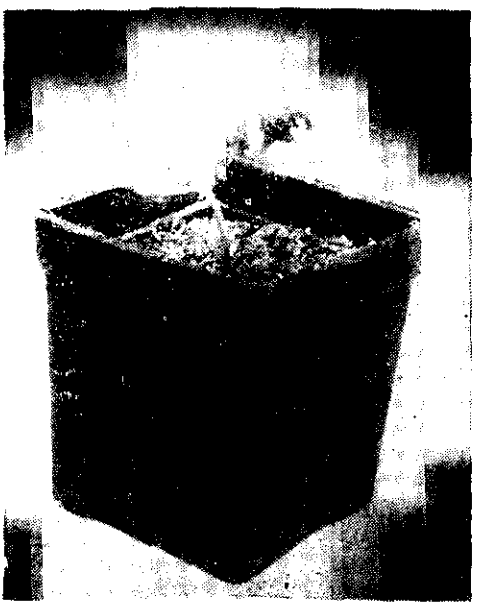

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Legends

Fig. 1. Micropropagation through nodal segments culture of *M. azedarach*.

A. Two week old culture of nodal segments from sixth passage on MS + BA (0.5 mg/l).

B. One week old culture on half MS+NAA (1.0 mg/l) showing root formation.

C. A micropropagated plant, one month after transplantation.

For obtaining plantlets, well developed 2 to 6cm long shoots were excised and the basal region was trimmed before putting into root induction medium. NAA proved, to be the most effective among the various auxins tried for root induction. Besides the type and concentration of auxin, root induction is also influenced by the basal media strength and aeration. Half strength MS medium gelled with 0.7% of agar proved to be the best for promoting root growth while shoots failed to root in liquid medium.

Solidified half strength MS medium incorporated with 1.0 mg/l NAA induced good rooting in all cultures in one week. The micropropagated shoots were transferred to plastic pots containing sterile vermiculite. These were later transferred to the soil after hardening.

DISCUSSION

The tissue culture of forest trees has shown promise in obtaining regenerants and rapid clonal multiplication. The basic advantages of *in vitro* propagation lies mainly in the rapidity with which plant multiplication can be achieved in a relatively short period with less space. Another advantage is that micropropagation can be carried out throughout the year, irrespective of seasonal change. In the present case, this technique has been useful to overcome problems of seed germination and for maintenance of superior genetic stocks.

The protocol developed for the nodal segment culture of *M. azedarach* can be effectively used for rapid multiplication of this species. Single node explants from mature trees as used in this study are useful for genetic stability which might be otherwise disturbed if regeneration is obtained from callus cultures. Nodal stem segments carrying an axillary bud or excised axillary buds have also been used successfully as explants in some instances. Teak (Gupta *et al*, 1980) and *Dalbergia sissoo* (Datta and Datta, 1983) have also been propagated similarly using single node culture unlike the conventional shoot tip culture technique.

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COMPONENTS OF GENETIC VARIATION IN SOYBEAN (*GLYCINE MAX* (L.) MERRILL)

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ABSTRACT

In a 7×7 half diallel cross of soybean, study of genetic components revealed, important role of both the additive (D) and non-additive (H_1, H_2) components in the expression of days for 50 per cent flowering, branches/plant, mean internodal length and 100 seed weight in both F_1 and F_2 generations. Pods/plant, seeds/pod and seed yield/plant in both the generations were under the control of dominance. Over dominance was pertinent for majority of the characters. The mean direction of dominance (h_2) was positive in F_1 and negative in F_2. Alleles were distributed asymetrically for all the characters except mean internodal length in both and seed yield in F_2 generation. Graphical approach revealed partial dominance. The array points were widely distributed.

Key words: Additive, non-additive, dominance, gene action.

Yield, the genetic improvement of which is the primary concern of the plant breeder, is the product of number of component characters. It is imperative to investigate the nature and magnitude of gene action governing the inheritance of yield and each of the component characters. Such information will support the development of plant breeding strategy. Therefore, the present study was attempted to decipher the genetic architecture of yield and its components through genetic component analysis in F_1 and F_2 of a 7×7 diallel (excluding reciprocals) cross of soybean (*Glycine max (L.) Merrill*).

MATERIALS AND METHODS

Seven diverse varieties of soybean viz. Monetta, MACS 13, Kalitur, PL SO 24, EC 201, EC 95837 and JS 72-44 were crossed in all possible combination excluding reciprocals. The parents and F_1s and parents and F_2s, were grown in a randomized block design with three replications during *kharif* 1987 and *kharif* 1988 respectively. The F_1 experiment consisted of a single row of 3 m length, and the F_2 experiment consisted of 4 rows of 3m length with a spacing of 45 cm between rows and 10 cm between plants. Five plants from the parents and F_1s and 30 plants from F_2 progenies were selected randomly from each plot in each replication for recording the observations, viz., plant height (cm), number of branches/plant, number of nodes on main stem, mean internodal length (cm), number of pods/plant, number of seed/pod, 100 seed weight (g) and seed yield (g)/plant. Days for 50% flowering and maturity were recorded on plot basis. The genetic components and graphical analysis was made by the method given by Hayman (1954).

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TABLE 1. Genetic components of variation and related statistics

Genetic parameters and related statistics	Gener-ration	50 per cent flowering (days)		Maturity (days)		Plant height (cm)		Number of branches/plant		Number of nodes/Plant		Mean internodal length (cm)	
		Estimete	±S.E.	Estimate	± S.E.	Estimate	± S.E.	Estimate	± S.E.	Estimate	± S.E.	Estimate	±S.E.
E	F_1	0.548	± 3.157	1.853	± 3.550	5.783	+ 6.134	0.152	±0.70	1.108	± 1.254	0.060*	±0.023
	F_2	1.268	± 0.838	2.475	± 2.844	2.395	±16.330	0.122	±0.119	05575	± 0.887	0.031	±0.015
D	F_1	26.187*	± 8.930	118.474**	±10.041	333.661**	±17.351	3.275**	±0.199	5.988	± 3.547	0.313**	±0.066
	F_2	31.412**	± 2.372	74.929**	± 8.048	117.823	±46.189	1.996	±0.337	4.354	± 2.510	0.313	±0.043
F	F_1	-4.471	±21.271	11.874	±23.917	176.331**	±41.328	1.603**	±0.473	-1.134	± 8.448	0.185	±0.157
	F_2	4.830	±11.334	-5.891	±38.439	-79.081	220.750	2.452	±1.610	-3.546	±11.995	-0.035	±0.206
H_1	F_1	63.494**	±21.500	133.340**	±24.173	335.668**	±41.772	2.871	±0.478	16.621	± 8.539	0.495**	±0.159
	F_2	75.645*	±22.838	190.071	±77.452	821.152	±444.791	6.833	±3.244	50.561	±24.169	1.655*	±0.416
H_2	F_1	51.753**	±18.944	109 931	±21.300	291.673**	±36.807	1 885**	±0 412	14 408	± 7 524	0 458**	±0 140
	F_2	69.165*	±20 123	161.517	±68.246	752.439	±391.924	4.715	±2.858	42.064	±21.296	1.631**	±0.366
h_2	F_1	0.858	±12.724	-0.149	±14.306	63.449	±24.721	0.770	±0.283	0.106	± 5.033	0.189	±0.094
	F_2	-15.081	±13.516	-27.965	±48.837	-29.996	±263.234	-1.570**	±1.920	-7.437	±14.303	-0.420	±0.246
$(H_1/D)^{\frac{1}{2}}$	F_1	1.557		1.061		1.003		0.936		1.666		1.257	
	F_2	0.776		0.796		1.320		00.925		1.704		1.150	
$(H_2/4H_1)$	F_1	0.204		0.206		0.017		0.164		0.217		0.231	
	F_2	0.229		0.212		0.229		0.172		0.208		0.246	
K_D/K_r	F_1	0.896		1.099		1.715		1.707		0.892		1.604	
	F_2	1.220		1.221		0.591		4.951		0.614		0.907	
h_2/H_2	F_1	0.016		-0.001		0.218		0 408		0.007		0.412	
	F_2	-0.218		-0.173		-0.040		-0.333		-0.177		-0.258	
r(Yr,Wr+Vr)	F_1	-0.487		-0.264		-0.145		-0.487		0.321		-0.040	
	F_2	-0.722		-0.475		0.380		-0.772*		0.111		-0.067	
t for (b-0)	F_1	2.402		6.417**		6.473**		6.638**		2.193*		2.246	
	F_2	6.631**		4.718**		2.161		1.657		1.412		3.528*	
t for (b-1)	F_1	1.391		0.382		0.468		0.758		5.531**		-1.466	
	F_2	0.324		1.665		2.848*		1.260		3.571*		0.553	
heritability (ns) %	F_1	61.119		68.904		56.121		68.083		49.775		32.511	
	F_2	59.274		55.383		31.653		67.255		20.666		36.096	

TABLE 1. (Continued)

Genetic parameters and related statistics	Gener-ration	No. of Pods/plant		No. of seeds/pod		100 seed weight (g)		Seed yield (g) / plant	
		Estimates ± S.E.		Estimates ± S.E.		Estimates ± E.E.		Estimates ± S.E.	
E	F_1	241.863	± 180.551	0.035**	±0.009	0.328	± 1.032	10 523	±10.044
	F_2	32.023	± 31.215	0.012*	±0.004	0.456	± 0.482	1.874	± 1.577
D	F_1	745.569	± 510.676	0.037	±0.025	19.030**	± 2.919	56 740	±28.410
	F_2	353.275*	± 88.291	0.118*	±0.011	16.089*	± 1.364	9.582	± 4.460
F	F_1	-241.197	±1216.382	0.078	±0.060	5.710	± 6.953	20 993	±67.670
	F_2	-234.022	± 421.969	0.125	±0.052	22.504*	± 6.519	-2.544	±21.314
H_1	F_1	3515.374**	±1229.438	0.239**	±0.061	21.215**	± 7.028	294.745**	±68.396
	F_2	2579.841*	± 850.229	0.332*	±0.106	55.491*	±13.135	105.197	±42.946
H_2	F_1	3189.269**	±1083.308	0.189**	±0.054	18.467**	± 6.192	270.364**	±60.266
	F_2	2459.741*	± 749.171	0.277*	±0.093	42.662*	±11.574	102.238*	± 37.842
h_2	F_1	2937.549**	± 727.599	-0.017	±0.036	0.622	± 4.159	311.933**	±40.478
	F_2	-217.819	± 503.178	-0.159	±0.062	-6.254	± 7.774	-19.918	±25.416
$(H_1/D)^{\frac{1}{2}}$	F_1	2.171		2.544		**1.056**		2.279	
	F_2	1.357		0.889		**0.929**		**1.657**	
$(H_2/4H_1)$	F_1	0.227		0.198		**0.218**		**0.229**	
	F_2	0.238		0.209		**0.192**		**0.243**	
KD/Kr	F_1	0.861		2.433		**1.331**		**1.177**	
	F_2	0.605		4.428		7.102		0 852	
h^2/H_2	F_1	0.921		-0.089		0.034		1.154	
	F_2	-0.088		-0.572		-0.147		-0.195	
r(Yr,Wr+Vr)	F_1	-0.702		-0.065		0.254		-0.633	
	F_2	0.781*		0.241		0.663		-0.881**	
t for (b-0)	F_1	1.485		0.764		4.622**		4.061**	
	F_2	2.382		5.522**		6.383**		1.461	
t for (b-1)	F_1	3.200*		4.106**		1.992		8.762**	
	F_2	0.047		1 011		1.496		2.044	
heritability (ns) %	F_1	38.713		4.853		61.902		27.790	
	F_2	28.240		63.708		78.353		21.462	

*, ** – Significant at 5% and 1% respectively.

RESULTS AND DISCUSSION

The estimates for genetic components of variation and related statistics are given in Table 1. It was observed that, both the additive (D) and dominance (H_1, H_2) effects played important role for the expression of the characters, days for 50 per cent flowering, mean internodal length and 100 seed weight in both the generations. The high magnitude of H_1 and H_2 than D have conceived the non-additive genetic variation to be mainly responsible for these characters. In F_1 generation these components governed the characters days for maturity, plant height and number of branches/plant. Tbe high level of D than H_1 and H_2 for number of branches revealed important role of additive type of gene action. The characters number of pods/plant and number of seeds/pod were under the control of dominant gene action in both the generations. The non-significance of component D and significance of H_1 and H_2 for seed yield suggested the predominance of dominant gene action for this trait, which is also confirmed from lower values of heritability. These results are in agreement with those of Kaw and Menon (1983).

The estimate h_2 suggested that the mean direction of dominance was towards positive and negative side respectively in F_1 and F_2. This indicated that the impact of dominant genes contribution for increment was in excess in first and reverse was true in the second generation. Similar observations are also reported by Talwar and Singh (1983). Preponderance of dominant genes in both the generations for the characters number of branches/plant, number of seeds/pod and 100 seed weight was evident from the estimate F.

$(H_1/D)^{1/2}$ revealed overdominance for all but three characters (maturity, days, plant height and 100 seed weight) in F_1 and 5 characters in F_2. The overdominance observed may be due to particular combination of positive and negative alleles, or simply correlated gene distribution causing considerable inflation into apparent dominance (Hayman, 1954). The distribution of alleles with positive and negative effects ($H_2/4H_1$) was assymetrical for all the characters in both the generations excepting mean internodal length in both and seed yield in F_2.

The ratio of total number of dominant to recessive alleles in all the parents (KD/K) revealed that, dominant genes were in excess than recessives for most of the characters. h_2/H_2 revealed presence of at least one group of dominant genes for expression of seed yield in F_1.

The correlation coefficient between parental order of dominance (W_r+V_r) and parental measurements (Yr) were found to be negative for the traits days for flowering and maturity, branches and pods/plant and seed yield/plant in both the generations indicating that the positive genes were responsible and mostly dominant in the expression of these characters. Kaw and Menon (1983) also observed the negative correlations for seed yield and other component characters like number of seeds, pods and branches/plant.

W_r-V_r graphic analysis revealed that, the character number of branches, nodes and pods/plant, mean internodal length and 100 seed weight in F_1 and all characters except mean internodal length and pods/plants in F_2 were under the control of partial dominance as the intercept of regression line was positive for these characters. Compared with the average degree of dominance revealed by the ratio. $(H_1/D)^{1/2}$, 4 characters in F_1 and 7 characters in F_2 showed similar type of dominance (Table 2). The wide distribution of array points along the regression line for all the characters showed the presence of appreciable amount of diversity among the parents for the characters studied.

TABLE 2. Type of dominance from Wr-Vr graphical approach and average of dominance $(H_1/D)^{\frac{1}{2}}$ for 10 characters in soybean.

Character		Intercept of regression line		Type of dominance		Average degree of dominence $(H_1/5)^{\frac{1}{2}}$	
		F_1	F_2	F_1	F_2	F_1	F_2
1.	50% flowering (days)	—ve	+ve	OD	PD	OD	PD
2.	Maturity days	—ve	+ve	OD	PD	CD	PD
3.	Plant height (cm)	—ve	+ve	OD	PD	CD	OD
4.	Branches/plans (No.)	+vne	+ve	PD	PD	PD	PD
5.	Nodes/plant (No.)	+ve	—ve	PD	PD	OD	OD
6.	Internodal length (cm)	+ve	—ve	PD	OD	OD	OD
7.	Pods/plant (No.)	+ve	—ve	PD	OD	OD	OD
8.	Seeds/pod (No.)	—ve	+ve	OD	PD	PD	PD
9.	100 seed weight (g)	+ve	+ve	PD	PD	CD	PD
10.	Seed yield (g)/plant	—ve	+ve	OD	PD	OD	OD

OD = Over dominance, PD = Partial dominance, CD = Complete dominance.

Heritability ranged between 4.85 to 68.90 and 2.70 to 78.35 per cent in F_1 and F_2 respectively. The characters days for 50 per cent flowering and maturity, plant height, branches/plant mean internodal length and 100 seed weight had high heritability in both the generations which is in comoration with the results of Konwar and Talukdar (1984), Gamolin and Ala (1985) and Ecochard (1986).

The results of the present investigation have indicated simultaneous exploitation of additive and non-additive genetic components and biparental mating followed by recurrent selection would result into faster genetic improvement in soybean.

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EFFECT OF DUST FORMULATIONS ON INCIDENCE OF INSECTS AND GRAIN YIELD OF SOYBEAN (*GLYCINE MAX* (L.)MERR.) IN MADHYA PRADESH

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ABSTRACT

Field evaluation of six dust formulations against insect pests of soybean revealed that two dustings of quinalphos 1.5% one at 3-4 days after germination @ 15 kg per ha and second at 20 days after germination @ 20 kg per ha, were most effective in controlling insects and increasing grain yield.

Key words: Soybean, dust formulations.

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) is attacked by a range of insect pests throughout its growth stages (Peswani, 1971; Saxena, 1972; Singh and Singh, 1987; Singh *et al.*, 1987 and 1988) Considerable yield losses are caused if proper and timely control measures are not followed (Gangrade *et al.*, 1975; Thakur, 1985). Several control measures involving liquid formulations have been recommended for effective control of different insect pests (Singh and Dhamdhere, 1983; Bhattacharya, 1986) However, high cost of liquid formulations, has been the limiting factor for large scale adoption by the farmers. Dust formulations, besides being cheaper, give satisfactory results provided dusting is not immediately followed by rains (Singh and Singh, 1988).

A study was, therefore, carried out to evaluate some dust formulations for the control of some major insects pests of soybean.

MATERIALS AND METHODS

Field trials were conducted during *kharif* season of 1987 and 1988 in randomized block design with three replications, at National Research Centre for Soybean, Indore (M P). Six dust formulations (Table-1) were tested on variety PK 472. Two applications were done, first at 3-4 days after germination @ 15 kg/ha, and second at 20 days after germination @ 20 kg/ha, with the help of 'hand rotary duster'. Observation on the populations of grey weevil (*Myllocerus* sp.), blue beetle (*Cneorane* sp.), green semilooper (*Diachrysia orichalcea* Fabr.) and white fly (*Bemisia tabaci* Genn.) were recorded 24 hrs after each dusting. For grey weevil, green semilooper and blue beetle three random samples were taken on 1m×0.5m white muslin cloth by beating method. White fly population was recorded on one top, middle and one lower leaf on 5 randomly selected plants. Data on yield contributing/agronomic characters like plant height, number of pods per plant, grain weight per plant, 100 seed weight and grain yield were also collected. Statistical analysis was done with the help of PC computer.

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TABLE 1. Effect of insecticidal dusts on the population of some insects of Soybean

Insecticide	Dose (Kg a.i./ha)	Grey weevil (Adults/m row)	Blue beetle (Adults/m row)	Green semilooper (Larvae/m row)	White fly (Adults/m row)
Fenvalerate 0.4%	0.08	2.33 (1.68)	1.83 (1.52)	1.00 (1.22)	1.16 (1.28)
Malathion 5%	1.00	3.50 (2.00)	3.50 (2.00)	1.33 (1.35)	1.33 (1.35)
Endosulfan 4%	0.80	2.66 (1.77)	2.66 (1.77)	1.16 (1.28)	1.50 (1.41)
Quinalphos 1.5%	0.30	2.00 (1.58)	1.16 (1.28)	0.33 (0.91)	0.83 (1.15)
Methyl Parathion 2%	0.40	3.50 (2.00)	2.83 (1.82)	1.50 (1.41)	2.83 (1.82)
Phanthoate 2%	0.40	3.16 (1.91)	2.50 (1.73)	1.00 (1.22)	1.16 (1.28)
Control	—	11.16 (3.41)	9.66 (3.14)	8.50 (3.00)	10.00 (3.24)
S.Em.±		0.87	0.44	0.33	0.33
C.D. at 5%		2.68	1.36	1.02	1.03

Figures in parentheses are values transformed to $\sqrt{n + 0.5}$.

TABLE 2. **Indirect effect of insecticidal dusts on some characters and grain yield of Soybean.**

Insecticide	Dose (Kg a.i./ha)	Plant Height (Cm)	No. of Pods/ Plant	Weight of grains/plant (9)	100 Seed Weight (9)	Grain Yield (q/ha)
Fenvalerate 0 4%	0.08	46.88	53.4	11 44	13.43	22.67
Malathion 5%	1.00	46.11	50.3	9.80	12.26	20.86
Endosulfan 4%	0.80	48.44	60.1	12.93	13.36	22.94
Quinalphos 1.5%	0.30	49.33	67.9	12.85	14.40	24.63
Methyl Parathion 2%	0.40	49.77	56.7	12.06	12.80	20.29
Phanthoate 2%	0.40	46.66	5 48	9 98	12.73	19.98
Control	—	43.55	42.4	8.13	10.26	14.86
S.Em.±		2.80	3.14	1.02	0.31	0.62
C.D. at 5%		NS	9.70	3.08	0.98	1.92

RESULTS AND DISCUSSION

1) Effect on insect population

All the insecticides were found to be at par in controlling grey weevil, however, most effective was quinalphos with adult population of 2.00 per m row length. Population of blue beetle adults also, in quinalphos treated plots, was significantly low (1.16 adults per m row length) than in those treated with fenvalerate, malathion, endosulphan and methyl parathion. Similarly, quinalphos again proved to be superior in controlling green semilooper larvae (0.33 larvae per m row length) and white fly (0.83 per plant) over methyl parathion, but was at par with others. These results were in confirmation of earlier reports of Singh and Singh (1988).

2) Yield parameters

In all the six insecticides, number of pods per plant, grain weight per plant, 100 seed weight and grain yield were significantly more than in control (Table 2). However, differences in plant height were not significant. Maximum grain yield was obtained in the plots dusted with quinalphos 1.5% followed by endosulphan 4% fenvalerate 0.4%, malathion 5%, methyl parathion 2% and phenthoate.

Highest grain yield (24.63 q/ha) in case of quinalphos 1.5% could be attributed to highest number of pods per plant (67.99), 100 seed weight (14.40) and significantly higher grain weight per plant (12.85).

Conclusively, two applications of quinalphos 1.5% dust, first at 3-4 days after germination @ 15 kg/ha and second at 20 days after germination @ 20 kg/ha would be effective control measure of insect pests of soybean like grey weevil, blue beetle, green semilooper and white fly in 'Malwa' region of Madhya Pradesh.

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Short Communication

INHERITANCE OF FUSARIUM WILT RESISTANCE IN LINSEED

Investigations on the mode of inheritance of resistance to wilt (*Fusarium oxysporium* f.lini Boll) of linseed (*Linum usitatissimum*) indicated one to four genes responsible for the resistance (Singh *et al.* 1956, Jeswani and Joshi 1964 and Upadhyay, 1970). Looking to the variations reported in this regard, it was felt important to investigate the inheritance pattern of resistant varieties R-552 and RLC-6 (Kiran) which were developed and released at the Oilseeds Reserach Centre, Raipur.

The progenies of nine intervarietal crosses involving two wilt resistant (RLC-6 and R-552) and four commercial varieties (SPS 23-10, Bengal-64, R-7 and R-1141-4) which are susceptible were tested for wilt resistance under epiphytotic conditions in wilt sick plot developed by growing susceptible linseed varieties and adding to the soil the wilt inoculum comprising available physiologic races of *fusarium*. Notes on germination were recorded and final stand of the seedlings noted. Observations on wilt reaction

TABLE 1. Reaction of the parents and F_1 hybrids to wilt

MATERIAL	NUMBER OF PLANTS	
	Survived	Wilted
SPS 23-10	17	348
RLC-6	396	16
R-552	413	13
Bengal-64	22	392
R-7	0	382
R-1141-4	28	389
F_1 (SPS-23-10 × Bengal-64)	1	59
F_1 (SPS-23-10 × R-7)	0	71
F_1 (SPS-23-10) × R-1141-4	0	60
F_1 (RLC-6 × Bengal-64)	1	56
F_1 (RLC-6 × R-7)	3	63
F_1 (RLC-6 × R-1141-4)	1	58
F_1 (R-552 × Bengal-64)	2	49
F_1 (R-552 × R-7)	2	53
F_1 (R-552 × R-1141-4)	1	47

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were taken every week and the wilted plants were cut out. The wilting due to *Fusarium* infection was confirmed by isolating the organism from a number of wilted plants from the plot. The plants continued to wilt till 35 days after sowing. The number of plants were counted in each population as resistant and susceptible, based on survival and wilting symptoms respectively.

The resistant varieties showed wilt reaction from 0 to 4.8 per cent, while susceptible varieties sufferred heavily with 92.4 to 100 per cent infection. The wilt reactions of the parents and the F_1 hybrids (Table 1) indicated that the F_1s of all the crossess were susceptible. It was presumed that the resistance was due to recessive allele in RLC-6 and R-552. However, earlier reports indicated the dominant nature of wilt resistance (Jeswani and Joshi 1964; Jeswani and Upadhyaya, 1970 and Kamthan *et al.*, 1981).

The F_2 data (Table 2) involving the crosses of RLC-6 revealed that the wilt resistance was conditioned by a pair of recessive alleles, while the crosses involving R-552 indicated presence of two recessive alleles complimentary nature. Goray *et al.*, 1987 reported one dominant allele in R-552 for the resistance. The crosses involving the susceptible parent SPS 23-10 segregated in a ratio of 3 resistant:13 susceptible. Since resistant plants observed were both the susceptible parents, the presence of another dominant allele of inhibitory gene is expected in SPS 23-10. This inhibitory dominant allele of the gene may not be present in another susceptible parents (Bengal-64, R-7 or R-1141-4) as revealed in the crosses involving RLC-6 or R-522. Digenic segregation reported earlier indicated dominant nature. However, the inhibitory dominant allele of the gene and recessive nature of resistance were not reported earlier. The recessive allele identified in the present study may serve as a new source of resistance,. The genotypes of the varieties under study may be suggested as under.

TABLE 2 Disease Reaction to Linseed wilt in F_2 progenies of nine crosses.

Cross	Number of F_2		X^2	P value	Mode of Segregation
	Resistant	Susceptible			
SPS-23-10×Bengal-64	149	744	2.48	0.10–0.20	3:13
SPS-23-10×R-7	218	1071	2.85	0.10–0.20	3:13
SPS-23-10×R1141-4	238	1005	0.12	0.70–0.80	3:13
RLC-6×Bengal-64	394	1068	2.80	0.05–0.10	1:3
RLC-6×R-7	250	687	1.41	0.20–0.30	1:3
RLC-6×R-1141-4	107	439	2.12	0.10–0.20	1:3
R-552×Bengal-64	79	1350	1.26	0.30–0.50	1:15
R-552×R-7	102	1692	0.97	0.20–0.30	1:15
R-552×R-1141-4	90	1233	0.68	0.30–0.50	1:15

Parent	Phenotype	Proposed Genotype
SPS 23-10	Susceptible	R_1R_1 R_2R_2 R_3R_3 R_1R_4 Ir_1ir_1
RLC-6	Resistant	r_1f_1 r_2r_2 R_3R_3 R_4R_4 ir_1ir_1
R-552	Resistant	r_1r_1 R_2R_2 r_3r_3 r_4r_4 ir_1 ir_1
Bengal-64	Susceptible	r_1r_1 R_2R_2 R_3R_3 R_4R_4 ir_1ir_1
R-7	Susceptible	$r_1r_1R_2R_2R_3R_3R_4R_4ir_1ir_1$
R 1141-4	Susceptible	$r_1r_1R_2R_2R_3R_3R_4R_4ir_1ir_1$

Further studies involving progenies of the crosses of the SPS 23-10 on one hand and the other resistant parental material as well as the back crosses and F_3 generations are necessary to finally confirm the nature of resistance to wilt of linseed.

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EFFECT OF LIMITED IRRIGATION AND FERTILIZER ON MUSTARD YIELD

In medium black cotton soils of Madhya Pradesh, farmers having adequate irrigation facility raise wheat crop. But under limited water supply they need an alternative crop to wheat from yield and economic point of view. Among the rabi oil seed crops, cultivation of mustard was found more profitable even with limited water along with fertilizer application, (Singh *et al.*, 1985 and Samui *et al.*, 1986). There is a dearth of information on the response of mustard to limited water supply and fertilizer for Malwa region.

An experiment was therefore conducted during rabi seasons of 1986 and 1987 at Regional Agricultural Research Station, Mandsaur on a clay loam soil rich in nitrogen (467kg N), medium in P (15.2 kg P_2O_5 / ha) and high in K (583.0 kg K_2O/ha) content with pH 7.1. The treatments comprising five levels of irrigation and four NPK combinations were tested in a factorial RBD replicated 3 times. Nitrogen was applied in two split doses, one at sowing and the other at first irrigation, while Phosphorus and Potassium were applied at sowing. Mustard variety Varuna was sown at 35×10cm spacing on 2nd November in both the years.

Irrigation exhibited a significant effect on yield and yield attributes like plant height, number of branches, siliqua/and seed weight per plant of mustard in both the years. Two irrigations applied at 30 and 60 days after sowing were significantly superior to irrigations applied at 15 and 30 days after sowing and one irrigation applied either at 15 or at 30 days after sowing. Application of one irrigation at 30 days after sowing was found to be as good as two irrigations applied at 15 and 30 days after sowing (Table 1).

Fertilizer application had significant effect on yield and yield attributes (Ankineedu *et al.*, 1983). Application of 40+40+30 NPK kg/ha gave the highest yield of 12.44 and 15.85 q/ha in 1986 and 1987, respectively, beyond which there was a reduction in the yield of mustard. The yield variation was in tune with the variation in the yield components such as number of branches, siliqua and seed weight per plant and test weight (Ankineedu *et al.*, 1983).

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TABLE 1. Effect of irrigation and fertilizer on the yield and yield attributes of mustard

Treatment	Plant Height (cm)		Branches/ plant (No.)		Siliqua/ plant (No.)		Seed weight/ Plant (g)		1000 Seed weight (g)		Yield (q/ha)	
	1986–87	87–88	1986–87	87–88	1986–87	87–88	1986–87	87–88	1986–87	87–88	1986–87	87–88
Irrigation												
No irrigation	165.7	128.3	9.2	10.2	143.8	135.3	8.84	10.48	17.45	19.42	9.15	12.02
One irrigation at 15 DAS	171.1	137.3	11.5	12.7	148.3	142.7	10.86	11.82	18.47	19.45	10.53	12.40
One irrigation at 30 DAS	175.8	153.2	15.1	16.1	213.3	207.1	12.24	15.90	18.47	19.50	11.11	14.61
Two irrigations at 15&30 DAS	178.7	152.2	17.00	17.7	223.2	220.6	13.34	16.52	18.57	19.77	12.77	15.86
Two irrigations at 30&60 DAS	209.8	165.9	19.5	20.5	242.2	256.4	18.01	21.02	18.90	20.85	14.67	19.57
C.D. at 5%	8.27	3.17	0.98	1.06	5.05	6.46	1.36	0.94	.31	.66	0.94	0.84
Fertilizer NPK (kg/ha)												
0– 0– 0	174.0	142.3	12.8	13.8	122.7	180.4	11.32	13.65	17.52	18.36	10.44	13.30
40–40–30	184.1	149.5	16.0	16.3	129.2	196.2	13.48	15.75	17.72	20.06	12.44	15.85
60–60–40	183.4	150.0	16.0	16.0	128.9	197.1	13.27	15.85	17.72	20.20	12.22	15.47
80–80–50	182.2	147.6	15.9	15.6	129.1	196.2	12.56	15.34	17.94	20.58	11.48	15.22
C.D. at 5%	7.39	2.85	0.84	0.95	4.51	5.78	1.21	0.83	0.26	0.57	0.84	0.76

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YIELD AND OIL CONTENT OF MUSTARD VARIETIES IN RELATION TO PLANT POPULATION

In crop production system optimising plant density to minimize competition for nutrients, light and moisture is essential. The optimum row spacing will be influenced by potential size and characters of individual plant of a variety for the maximum utilization of solar energy (Loomis and Williams, 1969). Information on plant characters of mustard varieties in relation to varying plant densities is scanty. The present study was therefore undertaken to asses the influence of plant densities on yield and oil content of mustard varieties under the agroclimatic situations of Gwalior.

Field investigations were made at the College of Agriculture, Gwalior during *rabi* seasons of 1989-90 and 1990-91. The soil was a sandy loam with pH 7.6, organic carbon 0.41 %, low in available nitrogen (183 kg N/ha), medium in available phosphorus (19 kg P_2O_5/ha) and high in available potash (273 kg K_20/ha). The treatments consisting of four varieties (Pusabold, Kranti, Varuna and Krishna) and four spacings (22.5 cm-4,44,000 plants/ha, 30.0cm-3,33,000 plants/ha, 37.5cm-2,66,000 plants/ha and 45.0 cm-2,22,000 plants/ha) were tested in a split plot design replicated four times. The crop received a basal dose of 40 kg N, 40 kg P_2O_5 and 20 kg K_20/ha. Nitrogen at 40 kg N/ha was applied as topdress after first irrigation. The crop was sown on 10 October in 1989 and 15 October in 1990. The gross plot size was 4.5×3.0m, while the net plot size was 4.05×2.60m for 22.5cm spacing 3.90×2.60m for 30.0cm spacing, 3.75×2.60m for 37.5cm spacing and 3.60×2.60m for 45.0cm spacing. The crop was harvested at maturity and data on yield and yield components were recorded. The oil content was estimated by Soxhlet oil extraction method (A.O.A.C., 1960).

Varieties

Pooled data of two years showed that mustard variety "Kranti" gave significantly higher seed yield (18.75 q/ha) than rest of the test varieties. However, variety "Pusabold" and "Varuna" remaining comparable to each other offered significantly greater seed yield than the variety "Krishna". The superior performance of "Kranti" can be attributed to substantially higher number of siliquae per plant, more seeds per siliquae and per plant seed yield. On the other hand, "Pusabold" had significantly more oil content (40.78%) and 1000 seed weight (6.31g) compared to the rest of the test varieties (Table 1).

Row spacing:

There was an increase in seed yield with increase in row spacing from 22.5cm (4,44,000 plants/ha) to 37.5cm (2,66,000 plants/ha). However, yield response to spacing/plant density was significant up to 30cm row spacing (3,33,000 plants/ha). Low yield at 22.5cm row spacing (high density) could be due to competition of plants for availa-

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TABLE 1. Effect of varieties and row spacing on seed yield, yield attributes and oil contention mustard*

Treatments	No. of siliqua/ plant	No. of seeds/ siliqua	Weight of sceds/plant (g)	Seed yield (q/ha)	1000 seed Neight (g)	O l content (%)
Varieties						
Pusabold	246.68	13.50	15.28	17.09	6.31	40.78
Kranti	281.96	14.93	17.46	18.75	5.81	39.87
Varuna	226.75	13.13	14.90	16.90	5.26	39.07
Krishna	185.20	11.78	13.41	14.74	4.13	38.75
S.E.m. ±	9.98	0.23	0.44	0.26	0.15	0.09
C.D. at 5%	30.14	0.71	1.36	0.81	0.46	0.28
Row Spacing (Plant density)						
22.5 cm (4,44,000 plants/ha)	225.16	12.50	13.52	14.35	5.08	39.10
30.0 cm (3,33,000 plants/ha)	233.46	13.10	14.78	18.30	5.28	39.14
37.5 cm (2,66,000 plants/ha)	253.53	13.55	15.67	18.47	5.37	39.21
45.0 cm (2,22,000 plants/ha)	228.43	14.18	17.08	16.35	5.78	39.38
S.E.m. ±	3.82	0.15	0.28	0.63	0.13	0.04
C.D. at 5%	11.48	0.46	0.84	1.88	0.40	N.S.

* Mean data of 2 seasons.

ble sunlight (Singh and Singh, 1987). Higher and comparable seed yield at 37.5cm and 30.0cm row spacing can be attributed to higher number of siliquae per plant (Wankhede *et al.*, 1970). Yield attributes like number of seed per siliqua and 1000 seed weight were also comparable in 37.5 and 30 cm spacing. Though 45.0cm row spacing gave maximum number of seeds per siliqua, 1000 seed weight, weight of seeds per plant and oil percentage; it failed to compensante for the yield loss due to lower number of plants per unit area. Oil content of mustard was unaffected by row spacings, though it exhibited an increasing trend with low density/wider spacing (Table 1).

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EFFECTS OF SOIL MOISTURE STRESS AT DIFFERENT DEVELOPMENTAL PHASES ON GROWTH AND YIELD OF SESAME.

Crop yield losses due to moisture stress at various stages in most of the crops have been reported by several authors. Not much information is available on sesame crop. As such a field experiment was conducted during summer season of 1990 (January through April) at Agricultural Research Station, Jagtial in randomized block design with three replications. The experimental soil was sandy loam, low in nitrogen (95 kg ha^{-1}) and phosphorus (13 kg ha^{-1}) and medium in potassium (300 kg ha^{-1}) and with a pH of 7.4. Its bulk density was 1.51 g cm^{-3}; it had 0.313 cm^3 cm^{-3} and 0.170 cm^3 cm^{-3} moisture at 0.03 MPa and 1.5 MPa respectively. No precipitation was received during crop growth period and no contribution from ground water since water table was at 10 deep. Recommended fertilizer dose (50N+40 P_2O_5+30 K_2O kg ha^{-1}) was applied. The sesame seed (Var. Rajeshwari) was sown on 25 January 1990 at 30cm×10cm spacing to achieve a desired population of 3.33 laks ha^{-1}. There were seven irrigation treatments designed to allow moderate or severe evapotranspiration deficits (ETd) at vegetative, reproductive and ripening growth phases as described in Fig. 1. Thus the seven treatments provided all the possible combinations (I-I-I, O_1-I-I, O-I-I, I-O_1-I-O-I, I-I-O_1, I-I-O) of growth stages in which ETd occured, ranging from none (I-I-I) to severe (I-O-I). The absolute ETd and its intensity in any given period depended on ETm rate. However, it would be much influenced by the water regime employed in prior growth stages. Thus the ETd during the reproductive period for treatment I-O-I was greater than for treatment I-O_1-I, both in absolute amount and in intensity. The measured quantity of irrigation water was scheduled by installing a 90° V-notch, at the field plot outlet. The soil moisture in the potential root zone depth (0-60cm) was monitored by gravimetric method by taking soil samples at two locations in each plot at 20cm intervals starting from planting to harvest, before and after irrigation and on intermediate dates as considered necessary. These measurements facilitated the estimation of crop ET.

The treatment I-I-I represented Ym, ETm plot a base for comparison (Table 1). Increasing intensities of moisture stress, caused a progressive deterioration in growth and yield. Leaf area index was significantly reduced even under moderate stress (I-O_1-I) when imposed at reproductive stage (35 days after sowing). Similar observations were made by Vyas *et al.*, (1987). Further it is well known (Begg and Turner, 1976) that one of the most important consequences of the sensitivity of cell enlargement to moderate water deficits is marked reduction in leaf area. Significantly lowest drymatter accumulation was also noticed at this stage, although moisture stress imposed at ripening stage also caused significant adverse effects on these growth traits. Further it is interesting to note again that seed yield was reduced significantly only at reproductive stage and this phenomenon seems to be directly linked with the significant reduction in capsules/plant, seeds/capsules and test weight. It is also note worthy that the drought coefficients

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TABLE 1. Yield and yield components of sesame as influenced by different intensities of soil moisture stress

Yield components	Treatments							SEm ±	C.D. (P=0.05)
	I-I-I	0_1-I-I	I-0-I	I-0_1-I	I-0-1	I-i-0_1	I-I-0		
Leaf area index*	2.62	2.61	2.43	1.75	1.53	2.42	2.29	0.16	0.49
Dry matter (g)	14.65	14.46	14.22	9.41	7.43	14.75	12.63	0.56	1.74
No. of capsules plant^{-1}	55.00	53.00	47.00	37.00	30.00	49.00	42.00	2.10	6.49
Seeds Capsules^{-1}	60.00	58.00	56.00	50.00	44.00	55.00	56.00	1.45	4.50
Test weight (g)	3.55	3.42	3.40	3.30	3.21	3.37	3.43	0.03	0.09
Seed yield q ha^{-1}	9.71	9.63	9.60	7.52	5.57	9.35	8.60	0.58	1.79
Crop evapotranspiration, cm.	26.20	25.66	25.40	21.14	19.57	25.01	25.53	—	—
Drought coefficient	—	99.17	98.86	77.44	57.36	96.29	88.56	—	—

* 70 days after sowing.

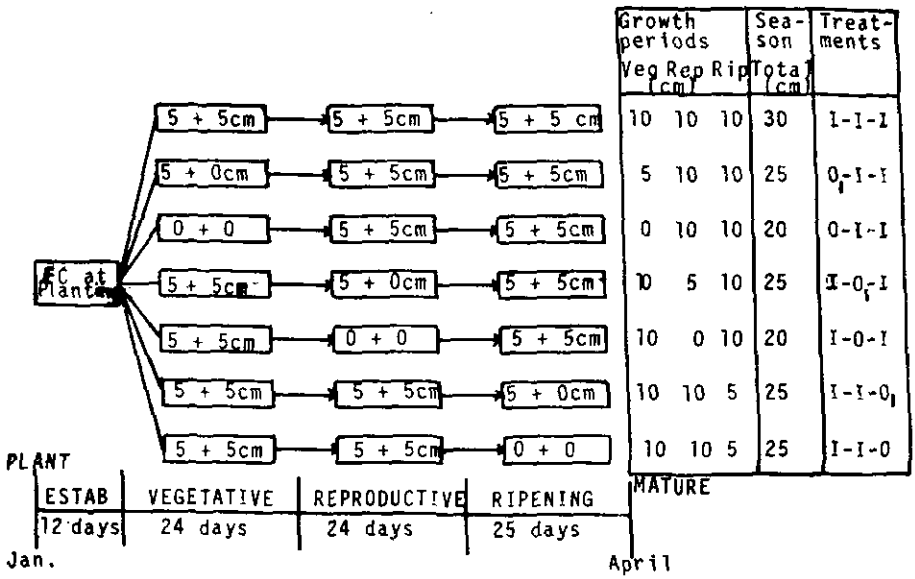

Fig.1. Irrigations treatments designed specifically to permit development of ET deficits in three growth periods of sesame.

(i.e., seed yield of stressed plots × 100/seed yield of unstressed plots) were also minimum when moderate and severe stress were imposed at reproductive stage. In sesame the yield is a composite of number of capsules/plant or unit area, seeds/capsule, and weight/seed and further it was seen that nearly 85% of sesame yield diversity was brought about by capsules/plant or unit area (Praveen Rao *et al.*, 1991). It appears, therefore, that water shortage at this stage resulted in an irreversable effect which could not be compensated during subsequent favourable soil moisture regime when the vital processes of capsule development remained in progress. In this regard, it has been speculated earlier by Matsuoka (1964) that moisture stress at this stage may lead to maximum reduction in yield was water absorption was found to increase from sowing with a maximum at reproductive stage. The reduction in seasonal ET under I-O_1-I and I-O-I treatment very well corroborate this observation. The body of data thus suggest that all the growth and yield traits studied were disturbed under moderates/severe stress imposed at reproductive and ripening stages to a small or large extent. This apparently contradicts the concept of Hsiao (1973) which suggests that different processes are affected at different ages of plant water potential. However, the conclusions arrived at by him were tentative because of varied reports obviously differing in experimental conditions.

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NITROGEN AND PHOSPHORUS FERTILIZER EFFECTS ON YIELD AND CONTENT OF NUTRIENTS IN SOYBEAN

Cultivation of soybean (*Glycine max* (L.) Merrill), which has 40% protein and 20% oil holds great promise to bridge the gap between demand availability of edible oil and protein. The potential of soybean for cultivation in Andhra Pradesh has attracted interest of farmers in recent years. Response of soybean to nitrogen and phosphorus has been reported by many workers (Satyanarayana, 1986 and Sinha *et al.*, 1987).

A pot culture experiment was conducted during rabi 1988-89 at Agricultural College, Bapatla, in split plot design to study the effects of nitrogen O (N_o), 50 (N_1), 100 (N_2) and 200 (N_3) kg Nha^{-1} and phosphorus 0 (P_o), 50 (P_1), 100 (P_2) and 200 (P_3 kg P_2O_5 ha^{-1} on seed yield and nutrients content (N,P,K,Ca,Mg & S) in soybean seeds.

The experimental soil was clayey in texture (Typic chromusterts), slightly alkaline (pH 7.8), low in available nitrogen (188 kg ha^{-1}) and medium in available phosphorus (11 kg ha-1). Nitrogen was applied as urea and phosphorus as single super phosphate. Total nitrogen in soybean seeds was determined by the method suggested by Bremner (1965). Phosphorus, calcium and magnesium contents of seeds were determined by the method of Jackson (1973). Potassium was determined by Flame Photometer (Muhr *et al.*, 1963) and sulphur by turbidity method (Cottenie *et al.*, 1979).

TABLE 1. Effect of nitrogen and phosphorus levels on seed yield (g/pot) (Means of three replications).

P levels	N_0	N_1	N_2	N_3	Mean
P_0	1.90	2.25	2.90	2.51	2.39
P_1	2.45	3.19	4.05	2.67	3.09
P_2	2.85	2.25	4.24	3.93	3.57
P_3	2.88	3.06	3.41	3.22	3.14
Mean	2.52	2.94	3.65	3.08	

	F test	C.D. at 5%	C.V.
P levels	Sig.	0.130	4.263
N levels	Sig.	0.105	4.100
P × N	Sig.		
2 N level means at same level of P			0.211
2 P level means at same or different level N		0.198	

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TABLE 2. Effect of nitrogen and phosphorus levels on N, P and K contents (mg/pot) in seed (Means of three replications).

	N content					P content					K content				
Treatments	N_0	N_1	N_2	N_3	Mean	N_0	N_1	$_2N$	N_3	Mean	N_0	N_1	N_2	N_3	Mean-
P_0	57.72	86.40	133.99	141.07	105.29	10.23	14.87	21.05	24.63	17.70	32.64	43.26	55.12	65.49	49.13
P_1	94.90	134.01	183.13	103.27	128.83	15.43	22.57	29.50	18.51	21.50	40.35	58.81	77.08	51.53	56.75
P_2	111 32	131 54	198 04	143 02	145 98	18 91	22 65	32 08	28 46	25 53	50 52	61.20	79.89	74.01	66.48
P_3	117.66	122.01	133.28	117.62	122.64	20.12	22.35	24.17	22.33	22.24	50.38	53.74	56.92	57.96	54.72
Mean	95 48	118 99	162 11	126 24		16 17	20 61	26 70	03 48		43 55	54 05	67 23	62 25	

	F test Sig.	C.D. at 5% 12.909	C.V. 18.281	F test Sig	C.D. at 5% 11282	C.V. 5.908	F test Sig.	C.D. at 5% 3.574	C.V. 20.522
P levels									
W le×els	Sig.	9.323	8.8*n*3	Sig.	1.119	6.108	Sig.	2.657	18.584
P×N	Sig.			S ig.			Sig.		
2 N levels meabr ffin m m aMe level of P		18.646			2.238			5.135	
2P level means at same or differeut level N		22.929			2.278			6.18	

TABLE 3. Effect of nitrogen and phosphorous levels on S, Ca and Mg contents (mg/pot) in seed (Means of three replicta Dons) Q

	S content					Ca content					Mg content				
Treatments	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean
P_0	2.86	4.70	9.86	12.88	7.38	7.63	11.45	15.04	15.49	12.40	9.24	13.06	18.08	22.36	15.69
P_1	3.84	6.92	14.03	8.88	8.29	11.46	14.08	22.70	14.20	15.61	11.31	18.76	22.79	15.08	16.98
P_2	5.99	10.41	17.39	12.18	11.49	15.61	17.81	30.03	20.18	20.98	15.71	19.49	24.25	19.75	19.80
P_3	6.52	7.34	8.75	7.94	7.64	12.29	13.92	18.65	14.63	14.87	17.48	18.68	19.70	16.66	18.31
Mean	4.60	7.34	12.55	10.35		11.75	14.31	21.60	16.20		13.44	17.50	21.20	18.46	
P levels		F test Sig.	C.D. at 5% 0.907		C.V. 10.435	F test Sig.	C.D. at 5% 1.074		C.V. 6.734	F test Sig.	C.D. at 5% 0.964		C.V. 5.468		
N levels		Sig.	0.059		6.943	Sig.	0.939		6.983	Sig.	0.964		5.005		
P×N		Sig.				Sig.				Sig.					
2 N levels means at same level of P			1.018				1.879				1.489				
2 P level means at same or different level N			1.533				1.909				1.677				

Soybean seed yield

The results revealed that applications of graded levels of nitrogen and phosphorus gradually increased seed yield from 0 to 100 kg ha^{-1} each (Table 1) and maximum seed yields were obtained, when 100 kg N ha^{-1} is applied along with100 kg P_2O_5 ha^{-1}. This might be due to increase in root proliferation resulting higher nutrient content leading to more number of pods and seeds per pot. Similar results were reported by Satyanarayana (1986).

Content of nutrients

The content of nutrients (N,P,K, Ca, Mg & S) in seed increased by nitrogen and phosphorus application from 0 to 100 kg ha^{-1} each (Table 2&3). These results were in agreement with findings of Vinod Kumar *et al.*, (1985) and Sinha *et al.*, (1987). However, maximum content of all these nutrients were recorded when 100 kg N ha^{-1} is applied in combination with 100 kg P_2O_5 ha^{-1}. This may be due to the positive interaction between nitrogen and phosphorus. Similar beneficial effects of nitrogen and phosphorus on nutrient contents was reported by Sharma and Dixit (1987).

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CORRELATION STUDIES IN INDIAN MUSTARD (*BRASSICA JUNCEA* L. CZERN AND COSS)

The mustard (*Brassica juncea* L. Czern & Coss) genotype 'Pusa bold' was selected from a cross involving an early variety 'Varuna' and a late maturing bold seeded variety B.I.C. 1780 of mustard. This genotype has the plasticity to adjust in early as well as late maturing regions. If sown early (first week of October) it partly escapes diseases and pests due to early flowering and early pod formation. The genotype has been found suitable for general cultivation in eastern, western, central and northern parts of India. The variety pusa bold was released as a national variety due to its wide adaptability. The present paper deals with inter-character association for yield and yield attributes in this newly released variety under varied agronomic management.

The experiment was conducted during rabi seasons of 1983-84 and 1984-85 at Indian Agricultural Research Institute, New Delhi. The treatments comprising three levels of nitrogen (O, 40 and 80 kg N/ha), three levels of irrigation (No irrigation, irrigation at 0.3 IW/CPE and irrigation at 0.6 IW/CPE) as main plot and three levels of phosphorus (0,15 and 30kg p/ha) as sub plots were laid out in split plot design with two replications. Observation on yield attributes were recorded from 5 randomly selected plants/plot. A total of 54 observations were used to compute the correlation coefficient (Aljibouri *et al.*, 1958). The yield and yield determining characters namely Leaf Area Index at flowering, number of primary and secondary branches at harvest, number of siliqua per plant, number of seed per siliqua, weight of siliqua per plant, weight of seed per plant and 1000 seed weight were recorded.

Seed yield of mustard was positively and significantly correlated with Leaf Area Index, number of primary and secondary branches, number of siliqua per plant, number of seeds per siliqua, per plant weight of siliqua and seed (Table 1). Positive association between yield and yield attributing characters is also reported by other workers in mustard (Singh *et al.*, 1969; Reddy and Sinha 1987). Some of the component characters also showed positive and significant correlation among themselves. Leaf Area Index, the number of primary and secondary branches per plant were positively associated with the number of siliqua per plant. The number of primary branches per plant was also found to be positively correlated with the number of secondary branches. The number of siliqua per plant was positively associated with the weight of siliqua per plant as well as weight of seed per plant. Similarly, the weight of siliqua has also shown positive association with weight of seed per plant. Study also revealed that in both the years the correlation between the various traits is the same indicating the stable nature of the associationship. Further the present finding is Skin to the correlation reported by earlier workers in mustard (Singh *et al.*, 1969; Gupta, 1972:

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TABLE 1. Correlation coefficients between yeild and its attributes.

		Number of Primary branches/ plant at harvest	Number of secondary branches/ plant at harvest	Number of siliquae plant	Number of seeds per siliquae	Weight of siliqua per plant	Weight of seed per plantM	1000 seed weight	Seed yield
Leaf Area Index at flowering	I	0.496**	0.534**	0.671**	0.334*	0.698**	0.707**	0.073	0.667**
	II	0.397**	0.532**	0.637**	0.319*	0.681	0.622**	-0.204	0.590**
Number of primary branches per plant at harvest	I		0.531**	0.638**	0.190	0.591**	0.571	0.292'	0.419**
	II		0.490**	0.639**	0.315'*	0.621**	0.561**	-0.042	0.432**
Number of Secondary branches per plant at harvest	I			0.737**	0.760**	0.760**	0.746	0.187	0.651**
	II			0.835*	0.295*	0.815**	0.799**	-0.176	0.653**
Number of siliquae Per plant	I				0.172	0.808**	0.726**	0.190	0.752**
	II				0.442**	0.955**	0.919**	0.166	0.830**
Number of seeds per siliquae	I					0.425**	0.557**	0.224	0.295*
	II					0.518**	0.515**	0.060	0.403**
Weight of Siliqua/plant	I						0.774**	0.078	0.744**
	II						0.931**	-0.155	0.818**
Weight of seed per plant	I							-0.062	0.752**
	II							0.004	0.868**
1000 seed Weight	I								-0.101
	II								-0.057

I — 1983–84 * Significant at 5% level

II — 1984–85 ** Significant at 1% level

Reddy and Sinha, 1987). Thus, the study indicates that seasons and agronomic management has little effect on the association of characters in mustard.

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A NEW ALTERNATIVE HOST OF *TOXOPTERA AURANTII* (BOYER DE FONSCOLOMBE)

Toxoptera aurantii (Boyer de Fonscolombe) is ploy-phagous and has been recorded from over 120 plant species. It is particularly damaging to young citrus plants. It infests leaves and branches which become stunted or malformed (Nair, 1986). Besides citrus it also attacks other economically important species including tropical beverage and fruit crops, the reddish brown to black aphids have black and white banded antennae; they form dense, ant-attended colonies on young shoots and undersides of young leaves, causing slight distortion of stems and leaf mid-ribs. Large colonies produce an audible scraping sound when disturbed. *T. aurantii* transmits Citrus Tristeza virus and other virus diseases of citrus and coffee. The species is widespread in the tropics and subtropics, and occurs in glasshouses in temperate regions. Apparently the life cycle is entirely anholocyclic.

During the field visits of front line demonstrations of oilseed crops at Baidi in Rait block of district Kangra, Himachal Pradesh, Toria crop (*Brassica campestris* var. toria) was observed to be infested with the three species of aphids. The number of *Toxoptera auarantii* (Boyer de Fonscolombe), *Lipaphis erysimi* (Kalt.) and *Myzus persicae* sulzer are 14-18,20-26 and 15-20 per 10cm shoot of plant respectively. The presence of former aphid on *B. campestris* var. toria clearly indicates that it acts as an alternate host for *Aphis traveresi* (Delg) which has not yet been reported in the available literature (Martin, 1983; Nayar *et al.*, 1982 and Ullah, 1940).

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OCCURRENCE OF DUSKY COTTON BUG, *OXYCARENUS LAETUS* KIRBY (HETEROPTERA LYGAEIDAE: OXYCARENNINAE) ON SUNFLOWER.

Sunflower, *Helianthus annuus* L. has become a popular oilseed crop in Maharashtra. Several pests have been reported to infest this crop in different parts of the country (Lewin *et al.*, 1973; Rangarajan *et al.*, 1975 and Sandhu *et al.*, 1973).

Heavy infestation of *Oxycarenus laetus* Kirby was observed on summer sunflower crop at Oilseeds Research Unit, Punjabrao Krishi Vidyapeeth, Akola during 1988 and 1989. The population counts of adults was recorded at weekly intervals on variety Surya and presented in table 1.

TABLE 1. Weekly population of *O laetus* Kirby.

Year			
1988		1989	
Date of observation	Population/10 plants	Date of observation	Population/10 plants
21-4-1988	80	3-5-1989	184
26-4-1988	596	14-5-1989	108
3-5-1988	359	23-5-1989	104
9-5-1988	821	30-5-1989	143
18-5-1988	358		
24-5-1988	537		

It is revealed from the table that the pest occurred in huge number for quite a long period during both the years. It sucks the developing and matured seeds in the capitulum. The pest has been observed to multiply on matured seeds of sunflower and to reduce the oil content in the seed under laboratory conditions. This is the first record of this pest from the state of Maharashtra.

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EFFECT OF TIME OF SOWING AND PLANT DENSITY ON YIELD OF NIGER

Niger, though a minor oilseed crop in India, is of considerable importance for rainfed lands, with poor soil and coarse texture. Orissa is the largest niger producing state in India, contributing 36 per cent to the national production (Anon, 1987). The principal niger growing districts are Koraput, Phulbani, Keonjhar and Mayurbhanj which together account for 93 per cent of the area and production (Anon, 1985-86). Earlier research work showed that niger could be profitably grown during winter season as a non-irrigated crop in uplands of coastal Orissa (Nayak, 1985). Productivity of the crop could be greatly improved by ensuring timely sowing and optimum plant population in the field. The present study was undertaken to determine optimum time of sowing and planting density of rainfed niger in coastal Orissa.

The experiment was conducted during winter season of 1987-88 at the Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar, in a sandy loam upland soil having pH 5.2, organic carbon 0.37%, total nitrogen 0.032% available P 20.0 kg/ha and available K 180.0 kg/ha. Sixteen treatment combinations comprising four dates of sowing (September 1, September 16, October 1, October 16) and four plant population densities (1.66, 2.22, 3.33, 4.44 lakh/ha) were tried in randomised block design. Niger GA 10 was grown as the test crop variety. Required pant density could be maintained by sowing the seeds with row spacing of 60, 45, 30 and 22.5cm and later on, thinning the plants to intra-row spacing of 10 cm.

The crop sown on September 1 received maximum raintall of 346mm with gradual decline in rainfall as the sowing was delayed.

In general, there was progressive increase in number of branches and leaf area index (LAI) till 75 days after sowing irrespective of date of sowing and plant density (Table 1). Plant height continued to increase till 90 days after sowing. Delayed sowing reduced all growth and yield attribuitng characters progressively. Plant height, branch number, dry matter accumulation, LAI, capitula per plant, fertile achenes per capitulum and 1000-achene weight of October 16 sown crop were 31.7,27.8, 33.0, 15.8, 40.0, 38.7 and 17.2 per cent less than those of September 1 sown crop, respectively. Reduction in duration of vegetative and reproductive phases of late sown crop due to soil moisture stress might be responsible for the lower values. However, LAI and achene weight were less affected as compared to other attributes. Performance of indvidual plants was the best under the lowest planting density (1.66 lakh plants/ha). Number of branches, dry matter accumulation, and effective capitula per plant, and fertile achenes per capitulum of the thickest sowing (4.44 lakh plants/ha) were 29.0, 35.0, 25.5, and 17.8 per cent less than those of the thinnest sowing. Thick sown plants, however, were taller due to competition for light. Test weight of seeds was unaffected by the planting density. This is a factor not liable to major change in a particular genotype (Donald 1963).

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TABLE 1. Effect of date of sowing and plant density on growth and yield attributing characters of niger

Treatment	Plant height (cm)	Branches/plant (primary + secondary)	Leaf area index at 75 DAS	Dry matter accumulation at 50% flowering (g/plant)	Effective capitula/plant	Fertile seeds/ capitulum	1000-seed weight (g)
Date of sowing							
September 1	137.3	13.9	4.2	**13.1**	39.6	28.4	**4.83**
September 16	110.7	11.7	4.0	**11.2**	28.8	27.3	**4.50**
October 1	100.3	10.6	3.8	**9.1**	26.7	20.1	**4.36**
October 16	93.8	9.4	3.5	**8.8**	23.8	17.4	**4.00**
C.D. at 5%	6.0	0.8	0.1	**0.4**	3.2	1.8	0.27
Plant density (Lakh / ha)							
1.66	105.4	13.7	2.7	**12.9**	34.2	25.9	4.30
2.22	108.7	11.9	3.2	12.0	31.4	**23.5**	4.34
3.33	113.4	10.3	**4.3**	8.9	27.7	**22.4**	4.47
4.44	114.7	9.7	**5.3**	8.4	25.5	**21.3**	4.57
C.D. at 5%	6.0	0.8	**0.1**	0.4	3.2	1.8	N.S.

DAS = Days after sowing

TABLE 2. Effect of date of sowing and plant density on yield, oil content and monetary return of niger

Treatment	Seed yield (kg/ha)	Stalk yield (kg/ha)	Stalk-seed ratio	Harvest index	Oil content (%)	Net return (Rs./ha)	Benefit-cost ratio
September 1	493	1343	2.74	26.8	35.9	910	1.52
September 16	394	1179	3.00	35.1	35.7	402	1.23
October 1	336	1002	2.93	25.1	35.1	102	1.05
October 16	250	761	3.03	24.7	34.2	-346	0.79
C.D. at 5%	22	58	0.17	0.8	0.3	—	—
Plant density (Lakh/ha)							
1.66	311	939	3.02	24.9	35.4	112	1.07
2.22	352	1032	2.93	25.4	35.3	264	1.16
3.33	393	1135	2.89	25.7	35.2	345	1.19
4.44	416	1178	2.83	26.1	35.1	348	1.18
C.D. at 5%	22	58	NS	NS	NS	—	—

Seed and stalk yields were maximum in September 1 sown crop as compared to other dates by planting (Table 2). Sowing on September 16, October 1 and October 16 reduced seed yield by 20, 32 and 49 per cent and stalk yield by 12, 25 and 43 per cent, respectivey. Seed yield was more affected than stalk yield which resulted in wider stalk seed ratio and lower harvest index. Yield is a function of number of capitula per plant number of achenes per capitulum and test weight of achenes. Beneficial effect of early sowing on these yield attributing characters, resulted in higher seed and stalk yields.

The lowest planting density of 1.66 lakh plants/ha (60×10cm) produced the minimum seed (311 kg/ha) and stalk (939 kg/ha) yields, inspite of better performance of individual plants. Loss of individual plant vigour was compensated by increase density and the highest planting density of 4.44 lakh plants/ha (22.5×10cm) produced the maximum seed (416 kg/ha) and stalk (1178 kg/ha) yields, which were 33.8 and a 25.5 per cent more respectively than those of the lowest density. Closer spacing (25cm) was also conducive for higher yield of niger during *kharif* season under Semiliguda (Orissa) condition (Misra and Sahu 1988). Increase of seed yield due to increase in density was comparatively more than that of stalk yield resulting in higher harvest index and narrower stalk-seed ratio. The differences, however, were not significant.

Seed oil content was depressed by delayed sowing. The difference between oil content of September 1 and October 16 sown crops was 1.7 per cent. Sowing beyond October 1 caused greater reduction than the other dates. Similar observations were made by Singh *et al.* (1982). Plant density had no effect on oil content.

September 1 sown crop gave maximum net return (Rs. 910/ha) and benefit-cost ratio (1·52). Delayed sowing caused progressive reduction in both the values due to decrease in seed and stalk yields. Sowing of unirrigated niger beyond October 1 was not remunerative. Higher density of 3.33 and 4.44 lakh plants/ha gave almost equal and higher net return and benefit-cost ratio than the lower planting density of 2.22 and 1.66 lakh plants/ha. Of all the treatment combinations September 1 sowing with 3.33 lakh plants/ha was most remunerative closely followed by September 1 sowing with 4.44 lakh plants/ha.

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GENETIC COMPONENTS OF WHITE RUST RESISTANCE AND SEED YIELD IN INDIAN MUSTARD (*BRASSICA JUNCEA*)

Losses due to white rust caused by Albugo candida (Lev.) Kuntze in Indian mustard vary from 12 to 20 per cent under normal date of sowing and from 20 to 54.5 per cent under late sowing (Tripathi and Kaushik, 1978; Saharan *et al.*, 1984). Owing to high cost of fungicides, the most practical and feasible approach is to evolve the high yielding varieties which also possess resistance to white rust. As the understanding of the inheritance of disease resistance along with yield in the newly introduced resistanl source material are lacking, the present study was undertaken with a view to generate the genetic informaton on these aspects so as to evolve a suitable breeding strategy for incorporating the white rust resistance into agronomically superior genetic background.

The genetic material consisted of 12×12 diallel cross (excluding reciprocals) of resistant and susceptible lines of Indian mustard (*Brassica juncea*) of both Indian and exotic origin. Among these parental lines six viz EC 126745, EC 126746, EC 126741 and EC 126743-2 (from USSR). Domo-4 (from Canada) and RC 781 (from India) were resistant to white rust whereas RH 30, Varuna, Kranti, RH 785, Prakash and RH 7859 (from India) were susceptible to this disease. Sixty six F_1 progenies along with 12 parental lines were grown in a randomized block design in two replications under two different environments of normal and late sown conditions (October 22, 1985 and November 8, 1985, respectively). Each further consisting of natural and artificially created epiphytotic conditions. Thus, the experiment was laid under four different environments namely normal sown and natural conditions (E_1), normal sown and artificially created epiphytotic conditions (E_2), late sown and natural conditions (E_3) and late sown and epiphytotic conditions (E_4). In all these four environments each entry was grown in a single row of 6m length. The distance between rows was kept at 45cm and plant to plant distance within row was maintained at 15cm by thinning. The loam soil of the experimental plots was fertilized with 80 kg N/ha.

To ensure adequate disease pressure, articifical inoculation was done with white rust sporangia which were collected from infected leaves with a brush and suspended in pure, sterilized water. Before inoculation, sporangial suspension was kept for 3 hours at 10°c for sporangial germination. This inoculum was sprayed thrice in environment E_2 and E_4 at an interval of seven days at pre-flowering stage. The data for white rust intensity on the leaves were recorded on 20 plants of every entry in each replication after two weeks of flowering stage. Six leaves were taken from each of the 20 plants from different positions and disease score was recorded in six grades, namely, 0,1,2,3,4 and 5 representing 0,3,10,25,40 and more than 40 per cent leaf area covered by white rust pustules, respectively. Disease scoring was done as per AICORPO (1985) and Gemawat and Prasad (1969) by following expression.

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TABLE 1. Estimates of genetic components of variance for seed yield and white rust intensity under four environments in Indian mustard

Components of variation	Seed yield per plant				Per cent disease intensity			
	E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4
D	13.64 ±11.07	17.41** ± 2.972	4.676** ± 2.393	1.103 ± 1.794	888.66** ± 25.11	947.81** ± 29.50	661.87** ± 49.19	687.40** ±77.47
H_1	74.57** ±22.15	36.66** ± 5.946	25.87** ± 4.788	29.41** ± 3.589	609.68** ± 50.25	585.55** ± 59.02	695.00** ± 98.41	926.71** ±154.98
H_2	71.75** ±18.42	30.14** ± 4.946	22.60** ± 3.983	25.72 ** ± 2.986	580.29** ± 41.79	557.612** ± 49.10	764.00** ± 81.86	858.47** ±128.91
H_2	56.64** ±12.32	42.61** ± 3.307	21.85** ± 2.663	31.75** ± 1.996	518.23** ± 27.94	337.32** ± 32.83	501.29** ± 54.73	167.61** ± 86.19
F	-2.124 ±25.09	9.262 ± 6.736	-0.633 ± 5.425	-0.073 ± 4.066	-168.68** ± 6.92	-184.75** ± 66.87	-137.40 ±111.50	-129.97 ±175.68
E	2.612 ± 3.071	1.471 ± 0.824	0.375 ± 0.664	0.347 ± 0.498	5.986 ± 6.967	6.409 ± 8.184	4.484 ± 13.64	9.183 ± 21.48
Degree of dominance	2.338	1.451	2.353	5.164	0.828	0.786	1.024	1.161
Symmetry of genes	0.241	0.206	0.218	0.219	0.238	0.238	0.242	0.231
Proportion of dominance and recessive genes	0.935	1.449	0.944	0.987	0.794	0.779	0.816	0.849
Group of genes exhibiting dominance effects	0.758	1.414	1.144	1.234	0.893	0.605	0.743	0.195
h^2 (n.s.)	0.311	0.448	0.416	0.263	0.782	0.799	0.703	0.664
t^2	4.410	1.981	3.166	20.33*	0.793	0.804	3.049	3.810

*P = .05

**P = .01

$$\text{Per cent disease intensity} = \frac{\text{Sum of all numercial rating}}{\text{Total number of leaves observed} \times \text{Highest rating.}} \times 100$$

Per cent disease intentsity data was then subjected to Angular transformation as advocated by Fisher and Yates, 1957. Observations were taken for seed yield (g) on 10 competitive plants in each entry. Statistical analysis was carried out according to method proposed by Hayman (1954).

Analysis of Variance revealed significant differences among the progenies for white rust intensity and seed yield. The estimates of genetic parameters for both the traits are presented in Table 1. Both additive (D) and dominance variance (H_1) were significant in all the environments for both the characters except (D) in E_1 and E_4. Howevei, the magnitude of H_1 was relatively higher than D under late sown conditions for disease intensity and in all the environments for seed yield. The estimates of degree of dominance $(H_1/D)^{1/2}$ for white rust resistance revealed partial dominance under normal sown conditions and over dominance under late sown conditions whereas over dominance was obtained for seed yield in all the environments. The ratio $H_2/4H_1$ did not deviate from theoretical value of 0.25 revealing thereby the symmetrical distribution of positive and negative genes among the parents in all the four environments for both the characters. The ratio $(4\ DH_1)^{1/2}+F/(4\ DH_1)^{1/2}-F$ attained the value of less than unity which revealed that recessive genes were more frequently distributed than the dominant genes in the parents in all the environments for disease intensity whereas equal distribution of dominant and recessive alleles were indicated for seed yield. The ratio h^2/H_2 was less than unity, which was indicative of one major gene group for the control of disease intensity. These were more than unity meaning thereby two gene groups per seed yield. The heritability estimates in narrow sense were high for disease intensity where as it was moderate for seed yield in all the four environments which envisaged that simple pedigree selection would be effective for white rust ressistance inprovement in segregating generations of hybrids among the parents improvement in seed yield however, methods like S_2 selection and the reciprocal recurrent selection which capitalize on both type of gene actions could be effective. For simultaneous improvement of both seed yield and white rust resistance, biparental cross material generated through Indian × exotic crosses could be effectively exploited by simple pedigree selections.

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RESPONSE OF GROUNDNUT VARIETIES TO DIFFERENT DATES OF SOWING AND ROW SPACINGS

Importance of oilseeds in the country's economy is well known, so there is an urgent need to raise oilseed production in view of the large gap between demand and supply of edible oils. The dificit at present is being made up by imports at a great cost of the foreign exchange resources of the country. This gap can be mitigated only by increasing the oilseed production per unit area and by increasing the area under cultivation. The considerable area under groundnut cultivation during *kharif* and summer seasons and prsent research is also concentraied on it, but the production in *rabi* season would have a stabilizing influence on price behaviour because of the arrivals of the crop into market during off-season. Keeping in view, present study was initiated to ascertain the feasibility of groundnut cultivation and to identify the suitable variety and row spacing for *rabi* season.

A field experiment was conducted in *rabi* seasons of 1983-84 and 1984-85 at the college farm, GAU, Anand. The soil was sandy loam in texture, low in total nitrogen (0.032%), medium in phosphorus (48.0 kg/ha) and rich in potash 350 kg/ha) with pH value of 7.8. The treatments consisted four dates of sowing (1 Oct, 15 Oct., 1 Nov. and 15 Nov.) as the main plot treatments and two groundnut varieties (GAUG-1 and TG 17) and three row spacings (30, 45 and 60cm) as the sub plot treatments were laid out in a split plot design with four replications. Fertilizer dose of 25 kg nitrogen and 50 kg P_2O_5 per hectare was applied at the time fo sowing.

Pod yield of groundnut was significantly influenced by sowing date during both the years (Table 1). October 1, sowing produced significantly higher pod yield and the lowest was recorded with last date of sowing on 15 November in both the years. Similarly, pooled analysis shown early sowing of 1 and 15 October were at par and produced significantly higher pod yield over 15 November sowing. This might be due to low temperature during flowering and pod development stages which affected the pod yield in late sowing.

In contrast to this haulm yield was significantly higher under last date of sowing in both the years, whereas, it was significantly lower in early sowing of 1 and 15 October, which might be due to higher pod yield received in these treatments resulted into depressed vegetative growth and consequently low haulm yield (Reddy and Patil, 1980).

Number of pods per plant were higher due to early sowing (15 October and 1 October) and results were significant only during 1983-84.

Variety TG 17 was significantly out yielded GAUG-1 in respect of pod and haulm yield during both the years and pooled analysis (Table 1). While in contrast, number of pods per plant were significantly higher in variety GAUG-1 as compared to

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TABLE 1. Effect of sowing dates, varieties and row spacings on yield components of *rabi* groundnut

Treatments	1983–84			1984–85			Pooled		
	Pod yield (kg/ha)	Haulm yield (kg/ha)	No. of pod	Pod yield (kg/ha)	Haulm yield (kg/ha)	No. of pod	Pod yield (kg/ha)	Haulm yield (kg/ha)	No. of pod
Date of sowing									
1 October	2174.71	6356.42	28.71	947.42	3571.79	18.38	1561.06	4964.10	23.54
15 October	2118.13	6407.38	31.44	900.79	2795.00	20.63	1509.49	5500.90	26.04
1 November	1893.58	6538.88	21.66	836.92	4089.04	17.47	1365.25	5313.96	19.32
15 November	1792.92	8206.79	28.38	691.75	4486.75	18.16	1242.23	5447.06	23.27
C.D. at 5%	7.32	938.99	4.49	19.77	400.39	NS	190.84	NS	NS
Varieties									
GAUG-1	1974.44	6465.29	30.12	828.29	3225.60	20.82	1401.37	4845.45	25.50
TG 17	2015.23	7289.44	24.73	860.04	4245.69	16.50	1437.64	5767.56	20.62
C.D. at 5%	2.43	439.70	1.99	12.68	185.12	1.93	6.39	236.16	1.37
Row spacing (cm)									
30	2008.91	7188.56	25.46	844.84	3830.31	18.03	1426.88	5509.44	21.74
45	2002.44	6762.31	28.49	848.53	3701.25	19.26	1425.48	5231.78	23.87
60	1973.16	6681.22	28.33	839.13	3675.38	18.69	1406.14	5178.30	23.51
C.D. at 5% D X S	2.98	NS	2.44	NS	NS	NS	NS	NS	1.68
C.D. at 5%	4.87	NS	NS	NS	370.25	NS	15.65	NS	NS

TABLE 2. Interaction of sowing date and row spacing on pod yield of groundnut (kg/ha)

Sowing dates	Row spacing (cm)					
	1984-84			Pooled		
	30	45	60	30	45	60
1 October	2178.75	2180.63	2164.75	1556.25	1569.88	1557.06
15 October	2127.50	2122.63	2104.25	1518.44	1512.13	1497.81
1 November	1922.63	1915.75	1842.38	1382.63	1380.25	1332.88
15 November	1806.75	1790.75	1781.25	1250.19	1239.69	1236.81
C.D. at 5%		4.87			15 65	

TG 17 in both the years as well in pooled results which can be attributed to bold kernel isze of TG 17 (Annon., 1989).

Pod yield was significantly affected due to row spacing during 1983-84 only (Table 1). The maximum pod yield was recorded under closer row spacings. Similar trend was also observed under pooled analysis. This may be due to higher number of plants per unit area in closer row spacing (30cm) as compared to wider spacing (45 and 60cm). Similar results were also reported by Vishnumurthy, 1985.

Haulm yield was not affected significantly due to different row spacings in both the years and in pooled results. Number of pods per plant was significantly lower under closer spacing (30cm) in the year 1983-84 and in pooled results as compared to wider spacing (45 and 60cm) might be due to less shading effect in wider row spacings.

All the interactions were found non-significant except sowing date × row spacing. It was found significant in respect of pod yield during 1983-84 and in pooled results as well as in respect of haulm yield during the year 1984-85 (Table 1). The interaction of sowing date and spacing indicated that the maximum pod yield gained under 1 October sowing with 45 cm. spacing which was at par with row spacing of 30 and 60cm. While lowest yield was obtained in late sowing (15, Nov.) with wider row spacing of 60 cm (Table 2). Irrespective of row spacing, sowing on 1 October found significantly superior over rest of sowing dates with respect to pod yield. Similar trend was observed during 1983-84 pooled results.

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NITROGEN IMPROVES QUALITY OF HYBRID SUNFLOWER SEEDS

Availability of quality seeds has been one of the limiting factors in successful cultivation of sunflower. Good quality could be achieved by following suitable agronomic practices in seed production programme. Earlier studies indicated that by manipulation of nitrogen fertilizers, it is possible to produce quality seeds having good germination percentage and seed vigour (Lopex and Grabe, 1971; Maheswarappa, 1983). Further, sunflower crop receiving high levels of nitrogen and phosphorus, produced seeds which possess not only good germination but also uniform flowering and maturity (Belevestev, 1976). Hence, the present study was undertaken to evaluate the requirement of nitrogen fertilizer for BSH-1 hybrid seed production and its relation to seed quality.

The parental lines viz., CMS-234 (seed-234 (seed parent), RHA-274 (pollinator) were grown in two ratios of 3:1 and 4:1, three row spacings; 45, 60 and 75cm and three nitrogen levels; 45, 60 and 75 kg/ha. This trial was conducted at the Agricultural Research Station, Kathalgere during kharif 1981 under irrigated condition.

The experiment was laid out as Randomized Complete Block Design with 3 replications in plots of 3 ml length and 12 to 12.6 wide depending on the ratio. Soil of the experimental site was red sandy loam to gravelly and the depth varying from 2' to 4'. The previous crop was ragi and initial fertility status of the soil was organic carbon 0.57 per cent, available phosphorus 33 kg/ha and available potash 160 kg/ha with pH 7.6. The entire quantity of phosphorus (90 kg/ha), potash (60 kg/ha) and 50 per cent of nitrogen was applied at the time of sowing and the remaining 50 per cent nitrogen was applied after 30 days. Hand pollination was carried out on alternate days during flowering and two bee colonies were also maintained in the experimental area. The biometrical observations were collected from five random plants in each plot and the yield data was collected from net plot area.

Seed quality parameters, germination percentage, test weight and vigour index were determined by the methods described by International Seed Testing Association (Annonymous, 1972). The seed nitrogen content was determined by micro-kjeldhal's method (A.O.A.C., 1980) and multiplied by 6.25 to get an estimate of crude protein content. Correlation coefficients were computed among the quality parameters and subjected to 't' test.

The results of the present study clearly indicated that there was a linear relationship between quality parameters and nitrogen application (Table 1). However, the interaction between spacing and nitrogen application was not significant (Table 2). There was a strong positive correlation between increased N application and seed qualities (Table 3). An increase of 9.2 per cent in protein content due to 30 kg extra app-

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TABLE 1. Effect of fertilizer levels on the seed quality of sunflower hybrid, BSH-1.

Fertlizer level (kg/hectare)	100 seed weight (g)	Germination per cent	Vigour index	Protein (%)
45	4.40	81.44	6693.26	22.06
60	4.61	87.90	8188.16	23.23
75	4.78	92.33	9507.59	24.09

TABLE 2. Interaction of spacing and N fertilizer level on the seed quality of sunflower hybrid, BSH-1.

Seed quality parameters/Spacing		F_1	F_2	F_3
A.	100 seed weight (g)			
	S_1	4.14	4.45	4.60
	S_2	4.59	4.76	4.92
	S_3	4.46	4.63	4.83
		S.Em.±	C.D. at 5%	CD at 1%
	SxF	0.13	NS	NS
B.	Per cent germination			
	S_1	81.73	90.37	91.70
	S_2	82.65	87.10	92.97
	S_3	79.95	86.28	92.30
		S.Em.±	C.D. at 5%	C.D. at 1%
	SxF	0.75	2.14	2.88
C.	Protein (%)			
	S_1	21.81	23.22	24.07
	S_2	22.39	23.23	24.24
	S_3	22.00	23.26	23.95
		S.Em.±	C.D. at 5%	C.D. at 1%
	SxF	0.16	NS	NS
D.	Vigour index			
	S_1	6804.38	8427.20	9311.31
	S_2	7085.31	8125.55	9794.39
	S_3	6191.10	8011.23	9417.10
		S.Em.±	C.D. at 5%	C.D. at 1%
	SxF	208.90	NS	NS

Spacing: S_1 = 45 cm; S_2 = 60 cm; S_3 = 75 cm.

Fertlizer level: F_1 = 45 kg; F_2 = 60 kg; F_3 = 75 ka per hectare.

TABLE 3. Correlation matrix of fertilizer level with seed quality parameters of sunflower hybrid BSH-1.

	1	2	3	4	5
1. Fertlizer level	1.00	0.69**	0.92**	0.95**,	0.95**
2. 100 seed weight		1.00	0.63**	0.70**	0.77**
3. Per cent germination			1.00	0.94**	0.93**
4. Vigour Index				1.00	0.92**
5. Protein (%)					1.00

**Significant at 0.01 per cent.

lication of N has resulted in 42.0 per cent increase in seed vigour. The seed protein content and seed vigour in sunflower has been reported to show positive reponse to enrichment of nitrogen and the correlation between seed protein content and seed vigour is found to be highly significant (Belamy and Chapman, 1981; Maheswarappa, 1983; Srivastava, 1978). It is reported that increased protein content in the seed is required for vigorous and healthy growth of seedlings and plants will exhibit uniform flowering and maturity (Belevestev, 1976; Thomas and Roger, 1979). The results of the present study are found to be in line with the earlier reports. The germination per cent and vigour index show highly significant and positive correlation with the seed protein content of sunflower hybrid BSH-1. Based on this information and the overall results obtained in the present study, it can be suggested that row to row spacing of 60 cm and application of 75 kg N per hectare is ideal to produce good quality BSH-1 seed with high vigour index.

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INTERCROPPING OF SUNFLOWER IN GROUNDNUT THROUGH ADJUSTMENT IN PLANT DENSITY

The high degree of instability in production of groundnut is mainly due to plant stands particularly under rainfed conditions. Results of various experiments on plan population of groundnut revealed no or little difference among population levels. Groundnut also offers good scope for intercropping with various other kharif cereals, pulses and oilseeds, Samui and Roy (1990) observed 12 to 76 per cent yield advantage and net profit in groundnut + sesame paired row arrangement, 81-85 per cent in groundnut + sunflower (1:2) and 50 - 57 per cent in the same crops in the ratio of 2:1 under dryland conditions at Kalyani (West Bengal). The possibility of growing an intercrop for every fourth vacant row has been advocated by Srivastava and Prasad (1984) as it resulted in saving of seed cost of groundnut to the extent of 25% without reduction in pod yield.

While reviewing the possibilities of increasing production of groundnut through its introduction in intercropping, Reddy (1990) recommended successful intercropping of groundnut with sorghum, sunflower castor and other crops with different row arrangements, minimising risks in production and maximising returns. The reduction in seed cost of groundnut and feasibility of introducing short duration oilseed crop like sunflower in it is vital to improve the production of oilseeds under rainfed conditions.

Keeping this in view an experiment on intercropping of sunflower in groundnut was conducted by adjusting the plant density through inter and intra row spacings of groundnut under rainfed conditions.

The experiment was conducted at the research farm of the Directorate of Oilseeds Research, Hyderabad on sandy loam soils of pH 7.5, low in N and P and moderate in K. The experiment was laid out in randomised block design with four replications The treatments included four row adjustments of groundnut (Groundnut: Sunflower-1:1 2:1, 3:1 and 5:1) with a population range of 50 to 100 per cent and with or without intercrop of sunflower besides sole crops of groundnut and sunflower. The groundnut variety Phule Pragati and sunflower variety Morden were included.

A common fertilizer dose of 30 N, 60 P_2O_5 and 40 K_2O kg/ha to both groundnut and sunflower was applied as basal 2-3 cm below the seed at sowing. In addition, 30 kg N/ha was also top dressed to sunflower 30 days after sowing. The sunflower and groundnut crops were harvested in the last week of September and October, respectively.

The rainfall received (562.9mm) was less than the normal and distribution was erratic. However, rain received during July (97.0mm) and September months (175.0mm) helped for better growth and development of sunflower, although groundnut suffered due to moisture stress at flowering and pod development stages which coincided with the meagre rainfall months of August (41.1mm) and October (37.5mm)

TABLE 1. Yield and Land Equivalent Ratio as influenced by various plant density levels in groundnut intercropping system.

Treatments	Groundnut population (%)	Yield (kg/ha)		Land Equivalent Ratio	Total Returns (Rs/ha)
		Groundnut	Sunflower		
1) Groundnut+sunflower 1:1 X S1	(50)	220	—	—	1391
2) Groundnut+Sunflower 1:1 X S2	(100)	260	—	—	1643
3) Groundnut+Sunflower 1:1 O S1	(50)	282	786	1.31	1782+ 3930
4) Groundnut+Sunflower 1:1 O S2	(100)	351	685	1.31	2219+ 3425
5) Groundnut+Sunflower 2:1 X S1	(67)	292	—	—	1846
6) Groundnut+Sunflower 2:1 X S3	(100)	297	—	—	1877
7) Groundnut+Sunflower 2:1 O S1	(67)	331	628	1.22	2092 3140
8) Groundnut+Sunflower 2:1 O S3	(100)	455	558	1.35	2876+ 2790
9) Groundnut+Sunflower 3:1 X S1	(75)	419	—	—	2648
10) Groundnut+Sunflower 3:1 X S4	(100)	429	—	—	2712
11) Groundnut+Sunflower 3:1 O S1	(75)	312	562	1.12	1972+ 2810
12) Groundnut+Sunflower 3:1 O S4	(100)	353	267	0.87	2231+ 1335
13) Groundnut+Sunflower 5:1 X S1	(83)	246	—	—	1555
14) Groundnut+Sunflower 5:1 X S5	(100)	284	—	—	1795
15) Groundnut+Sunflower 5:1 O S1	(83)	328	358	0.93	20.3+ 1790
16) Groundnut+Sunflower 5:1 O S5	(100)	422	344	1.07	2667+ 1720
17) Groundnut+Sole S1		597	—	—	3774
18) Sunflower Sole S6		—	943	—	4715
C.D. at 5%					1122.3

Plant to plant spacing in groundnut (cm) — S1 — 10, S2 — 5, S3 — 6.7, S4 — 7.8, S5 — 8.3; Sunflower: S6— 20, X = No intercrop, O = Intercrop Price of produce (Rs/q) during 1987: Groundnut = 632.08, Sunflower = 500.00.

A perusal of the data (Table 1) revealed the maximum yield of groundnut (597 kg/ha) and sunflower (943 kg/ha) when grown as sole crops. Under intercropping system, maximum yield of groundnut was observed in 2:1 proportion (455 kg/ha) when the plant density of groundnut was 4.44 lakhs/ha, while intercrop of sunflower recorded the highest yield (786 kg/ha) in 1:1 proportion. This might be due to higher plant population of sunflower in the system. Maintenance of 100 per cent of the recommended groundnut population with sunflower as intercrop in 2:1 prportion resulted in higher yield of both the crops. This treatment also registered the higher land equivalent ratio (LER:1:35) over other intercropping combinations with variable plant density. Groundnut + sunflower (1:1) combination having 50% of the groundnut population and higher population of sunflower was also equally effective resulting in higher LER. Variation in yield and LER due to changes in plant density of groundnut intercropping system is reported by Srivastava and Verma (1985) and higher yields of groundnut + sunflower along with higher net returns by Samui and Roy (1990).

TABLE 2. *Mean yield and total returns in intercropping of groundnut+sunflower*

Row ratio/skip row or intercrop		Yield[a] (kg/ha)		Total Returns, (Rs/ha)
		Groundnut	*Sunflower*	
1:1 X		240	-	1517
1:1 O		316	735	5678
	Mean:	278	735	3597
2:1 X		294	-	1861
2:1 O		393	593	5449
	Mean:	343	593	3655
3:1 X		424	-	2680
3:1 O		332	414	4174
	Mean:	378	414	3427
5:1 X		265	-	1675
5:1 O		375	351	4125
	Mean:	320	351	2900
Sole Crop: Groundnut:		597		3774
Sunflower:		943		4715
Groundnut with skip row		306		1933
Groundnut with sunflower		354		4857

X = No intercrop (skip row); O = Intercrop of sunflower.

The data on mean yields and returns (Table 2) indicated that:

— introduction of sunflower in groundnut as an intercrop was desirable over sole cropping both in terms of yield and returns;

— it is desirable to introduce an intercrop like sunflower than leaving the rows vacant;

— Highest mean monetary returns could be obtained with 2:1 row ratio (Rs. 3655/ha) followed by 1:1 row ratio (Rs. 3597/ha) among different row ratios; and

— sunflower is better than groundnut among sole crops;

In view of the advantages of intercropping under dryland conditions, sunflower could be successfully cropped after every 2 to 5 rows of groundnut while maintaining the recommended population of groundnut for increasing the oilseeds production.

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RESPONSE OF GROUNDNUT CULTIVARS TO TIME OF SOWING IN DIFFERENT SEASONS

Groundnut crop sufferes yield reduction due to moisture stress (Lenka and Misra 1963), delayed sowing (Ghosh and Das Gupta, 1975 and Patel *et al.*, 1986), seasons (Madhusudana Rao, 1988) and differential response of cultivars. Differential response of various yield components to above factors usually encountered in the cultivation of groundnut formed the basis for the present investigation.

Two field experiments were conducted during *kharif* and *rabi* seasons of 1987 on red sandy loams of College of Agriculture, Hyderabad to assess the effect of irrigations (no irrigation and irrigation at IW/CPE of ratio of 0.8 with 5 cm depth of irrigation), Cultivars (Gangapuri, JL 24, Kadiri-3 and M-13) and 3 dates of sowing (19 June, 14 July and 8 August, 1987) on the yield of groundnut during *kharif* in Split - split plot design with three replications. During *rabi* 1987, the same four cultivars used in *kharif* were used as main treatments and dates of sowing formed sub-plot treatments (25 October, 19 November and 14 December, 1987) of split-plot design replicated thrice.

The *kharif* rainfed crop registered lower values for number of filled pods (1.0) (Lenka and Misra, 1963), shelling per cent (12.4) 100-kernel weight (6.7g) and pod yield (11 q/ha) (Pandey *et al.*, 1984). Such reduction in pod number, shelling per cent, 100-kernel weight and pod yield was documented with moisture stress. The effect of moisture stress was less pronounced on number of filled pods (7% reduction) and more pronounced on 100-kernel weight (32% reduction), shelling per cent (20% reduction) and pod yield (30% reduction) (Table 1). Among the yield components, pod filling was most affected while pod number was least affected under moisture stress conditions. Among the cultivars, K-3 followed by M-13 performed better under rainfed conditions than JL 24 and Gangapuri, if sowings were delayed up to July. If sowings were further delayed up to August JL 24 and K-3 performed better than Gangapuri and M-13 presumably due to lesser duration of crop and escape low temperature during pod fiillng phase.

In *rabi* experiment the duartion of crop was also delayed by five days for all the cultivars except M-13 which was delayed by 8 days. The late sown crop yielded less than the early sown crop in both the seasons. There was a significant cultivar × sowing interaction where pod yield decreased significantly in delayed sowings. Under normal sowing conditions with irrigation, maximum pod yields were recorded in both the seasons and the values being 47.4, 35.3, 30.1 and 28.5 q/ha for K-3, M-13, JL 24 and Gangapuri, in *kharif* and the corresponding values for *rabi* were 51·7, 76.2, 38.5 and 58.0 q/ha (Table 2). The shorter growing season of *spanish* and *valencia* cvs typically contribute to their low yields (Duncan *et al.*, 1978). Similar results were obtained with JL 24 and Gangapuri in the present studies during *kharif* season. However, in

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TABLE 1. Yield and components of groundnut as affected by genotype, planting date and irrigation during *kharif*, 1987.

Treatments		Filled pod number/plant		100-pod weight (g)		100-kernel weight (g)		Shelling per cent		Pod yield (q/ha)		Harvest Index	
		1	2	1	2	1	2	1	2	1	2	1	2
Gangapuri	D_1	13.5	14.2	53.5	63.4	13.9	20.5	51.9	64.7	22.0	28.5	30.7	33.0
	D_2	12.2	13.9	47.1	58.3	11.4	17.0	48.3	58.3	14.9	22.9	31.5	36.1
	D_3	11.0	12.2	46.7	57.8	11.0	16.3	47.2	56.4	12 3	18.8	32 0	36.0
JL 24	D_1	12.4	13.2	60.4	72.6	14.8	24.2	54.6	66.1	22.2	30.1	33.9	36.3
	D_2	11.7	12.5	60.1	67.2	14.1	18.9	52.2	62.6	17.9	23.6	38.3	40.0
	D_3	10.5	11.5	60.0	65.3	13.4	17.6	49.7	60.0	16.0	20.1	42.4	40.0
Kadiri-3	D_1	16.2	18.4	77.7	81.9	19.2	25.7	54.8	69.7	34.3	47.4	48.0	48.8
	D_2	15.3	17.0	74.6	75.2	16.8	21.5	50.2	67.6	25.5	36.9	49.2	49.1
	D_3	13.8	15.5	70.0	67.9	14.4	18.4	45.6	60.1	20.9	29.7	46.6	50.1
M-13	D_1	12.5	13.8	67.8	93.6	15.7	27.9	51.6	66.2	23.4	35.4	34.4	37.6
	D_2	12.0	11.6	62.6	86.4	12.7	22.1	45.0	56.8	19.9	28.0	35.3	36.1
	D_3	12.0	11.3	62.1	80.0	11.5	18.8	41.1	52.3	13.3	23.6	37.7	40.8
C.D. at P = 0.05													
MT		0.6		0.51		0.3		1.7		0.13			
ST		0.3		0.21		0.4		1.2		0.98			
SST		0.2		0.23		0.2		1.2		0.69			
MT × ST		*0.5*		*0.29*		0.6		1.2		1.39			
ST × MT		*0.5*		*0.30*		*0.5*		*1.4*		*1.20*			
MT × SST		*0.2*		*0.32*		*0.3*		*NS*		*NS*			
SST × MT		0.3		0.30		0.3		NS		NS			
ST × SST		0.5		0.45		0.5		2.3		1.39			
SST × ST		0.5		0.41		0.5		2.2		1.44			
MT × ST × SST		0.6		0.64		0.6		0.8		1.46			

1=Unirrigated; 2=Irrigated; MT=Main treatment; ST=Sub-treatment; SST=Sub-sub treatment.

TABLE 2. Yield and components of groundnut as affected by genotype and planting date during *Rabi* 1987.

Treatments		Filled pods Number/ plant	100-pod weight (g)	100-kernel weight	Shelling per cent	Pod yield (q/ha)	Harvest Index
Gangapuri	D_1	15.1	116.6	43.3	76.7	58.0	58.5
	D_2	10.3	106.4	36.2	71.5	33.8	47.1
	D_3	8.4	93.0	25.3	58.2	23.1	40.7
JL 24	D_1	15.8	73.8	25.9	78.0	38.5	47.1
	D_2	12.5	72.5	22.1	67.9	32.0	43.7
	D_3	11.0	70.9	20.4	64.0	25.6	40.8
Kadiri-3	D_1	14.7	106.5	41.3	86.1	51.7	53.7
	D_2	12.9	94.6	32.4	76.2	40.0	47.8
	D_3	11.5	70.4	21.7	68.4	26.2	38.6
M-13	D_1	20.1	117.5	39.8	75.2	76.2	43.9
	D_2	14.3	103.2	30.3	65.3	47.7	37.4
	D_3	8.0	94.4	23.0	57.6	24.8	26.8
C.D. at P= 0.05							
Genotypes		0.4	9.2	0.4	3.6	6.9	1.39
Planting date		0.2	6.0	0.4	2.6	3.2	0.73
Genotype × Planting date		0.5	12.0	0.7	NS	6.5	1.46
Planting date × genotype		0.6	12.4	0.6	NS	8.6	1.76

rabi season Gangapuri performed better than K-3 in terms of 100-pod weight and kernel weight which ultimately resulted in high pod yield. Pod number increased constantly until the penultimate harvest. Pod number, shelling per cent, 100-pod weight and harvest index were more with cv. K-3 in *kharif* rainfed condition. Whereas, in *rabi* pod number was more with cv. M-13 and pod weight and harvest index with Gangapuri and these two cultivars revealed more yield potential than other cultivars when sown earlier.

The reduction in various yield components and pod yield due to delay in sowings was more in *rabi* crop than in *kharif* crop and also the 100 pod weight and 100-kernel weight in general suffered most in *kharif* suggesting that partitioning of photosynthates from source for the development of sink (pods) was adversely affected. During *rabi*,

besides the above parameters, late sown crop produced less number of pods. Several workers reported reduction in pod number (Ghosh and Das Gupta, 1975), shelling per cent (Reddy *et al.*, 1984), 100-kernel weight and pod yield (Patel *et al.*, 1986) due to delay in sowing. The reasons for such reduction were sharp decrease in temperature, rainfall and humidity at fag end of crop growth (Ghosh and Das Gupta, 1975) or reduction in pod production (Reddy *et al.*, 1984) or restricted development of yield attributing characters (Patel *et al.*, 1986).

Rabi crop recorded more 100-kernel weight and pod yield than *kharif* crop despite more number of filled pods in the later season (Madhusudana Rao, 1988). A positive correlation was observed between yield parameters and pod yields (Table 3).

TABLE 3. Correlation matrix of different characters with pod yield.

Character	Kharif	Rabi
Total pod number	0.60*	0.88*
Filled pod number	0.85*	0.91*
100-pod weight	0.60*	0.80*
100-kernel weight	0.80*	0.68*
Shelling per cent	0.87*	0.64*

* Significant (P = 0.05).

In *kharif* season the performance of cultivars K-3 followed by M-13 was more stable in irrigated as well as in rainfed conditions either with normal or delayed sowing. But the duration of M-13 (Virginia runner) is 27 days more than JL 24 and Gangapuri. However, for fitting into a multiple cropping system, a short duration cultivar like JL 24 can be chosen. In *rabi* season, under normal sowing conditions, M-13 followed by Gangapuri exhibited better yield performance. Kadiri 3 or Gangapuri can be preferred to M-13 Cultivars such as for delayed sowings.

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A NOTE ON THE EFFECT OF SELECTED BIOREGULATORY TREATMENTS ON SEED VIABILITY AND ASSOCIATED BIO-CHEMICAL CHANGES IN SUMMER GROUNDNUT (*ARACHIS HYPOGAEA* L.), CV: GG - 2

Groundnut seed deterioration under ambient storage conditon is an acute problem in Sausrashtra area in Gujarat State of India where high temperature and high humidity accelerate viability loss (Shah *et al.*, 1986). In order to overcome poor plant stand (due to lack of seed germination) higher seed rate is used. This increases cost of production. The problem of seed viability loss is even more acute in Rabi/Summer groundnut than in regular *Kharif* crop because temperature and relative humidity are higher during the storage period of June-October. For a very practical purpose, improving upon the germination quality of less viable seed has remained a profitable area of research in this field. Information on groundnut crop in this respect is extremely limited. In this paper the effect of selected bioregulators on seed viability, protein content and enzyme activity of storage groundnut seeds are reported.

Groundnut seeds of bunch type variety GG-2 harvested on May, 1987 from Experimental Research Station, Anand were stored for eight months in gunnny bagin the form of pods. The gunny bag was kept on cement shelf in ambient condition (temperature and humidity range being 38.5°C-24.4°C and 65%-86% respectively). Seeds were treated in January, 1988 at room temperature. Different treatments were imposed on individual lot of 500g kernels. For giving alcohol vapour treatment, 1 lit. Capacity desiccator was saturated with alcohol vapour by keeping the desiccator filled with 200 ml of pure absolute alcohol for 2 hours. Groundnut kernels were kept on perforated hardboard in alcohol saturated desiccator for 30 minutes. 25 ml. gibberellic acid in the form of progibb (10ppm solution) was sprinkled as fine spray on groundnut kernels which were thoroughly mixed. 25 ml of 0.1% H_2O_2 solution was sprinkled on seeds in the same way as in gibberellic acid treatment. For oxygen gas treatment O_2 gas was passed through 1 lit. flask containing groundnut kernels at 6 kg/Sq cm for 2, minutes. The flask was closed tightly immediately after passing the gas. The assembly was kept as such for three hours. Hot water treatment was given by keeping the groundnut kernels in 250 ml destilled water maintained at 41°C for 30 minutes. For cold water treatment kernel was soaked in 250 ml distilled water maintained at 9°C for three hours. Seeds were kept open to air (in room condition) on a filter paper for one day after alcohol vapour, gibberellic acid and H_2O_2 treatments; for three hours oxigen treatment and for ten days after hot and cold water treatments. This exposure was necessary to bring the seed lots to their original weights. Seeds were stored in filter paper packets for 40 days after which germination tests were conducted. For germination, seeds were first surface sterilised with 0.1% mercuric chloride solution and then kept for germination according to ISTA rules (Anon., 1976). Tests were conducted in triplicate with 50 seeds in each replication on 150 mm × 20 mm petri plates. α -amylase, isocitrate lyase and peroxidase enzyme activity were measured

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from the cotyledons of 5-days imbibed germinating seeds. ∝ amylase was estimated by the method suggested by Malik and Singh (1980. For isocitrate lyase Smith and Gunsalus (1957) method was adopted. Peroxidase activity was assayed following the method of Guilbaults (1976). Experimental data were statistically analysed.

Germination tests conducted after 40 days of treatment revealed that alcohol vapour, gibberellic acid and hydrogen peroxide treatments significantly improved seed germination over non-treated control in that order (Table 1). Treatment difference between gibberellic acid and H_2O_2 was, however, non-significant. Oxygen and hot water marginally altered per cent germination but cold water significantly reduced seed germinability over the control.

TABLE 1. Effect of bio-regulatory treatments on per cent germination and protein content (g/100g) of germinated and ungerminated seed embryos after 5 days of imbibation.

Treatments	Germination		Protein Content	
	% germination	% change over control	Germinated embryos	Ungerminated embryos
Alcohol vapour	76.7	+ 149.8	24.13	18.56
Gibberellic acid	52.7	+ 71.7	21.97	18.91
Hydrogen peroxide	46.0	+ 49.8	20.51	18.08
Oxygen	35.3	+ 15.0	22.64	17.04
Control	30.7	—	18.02	17.67
Hot water	20.7	— 34.9	15.20	14.61
Cold water	8.7	— 71.7	14.68	14.54
S.Em.	3.39		0.575	0.218
C.D. (0.05)	10.29		1.744	0.31
C.V. %	15.22		5.08	3.83

Chowdhury (1988) suggested that ethanol is a speciffic scavanger of OH- free radical. Thus, alcohol vapour might have reduced the chances of formation and lipid peroxidation products and other toxic substances by scavanging free radicals improving seed germinability. Brahma *et al.* (1978) suggested that gibberellic acid could counteract the inhibitory effect of abscisic acid and coumarin. The positive effect of the treatment on the viability of Summer groundnut seed could be due to such properties of gibberellic acid. Stimulating effect of hydrogen peroxide on the observed germinability could be due to accelerated rate of respiration by providing oxygen through H_2O_2 to the seeds.

Oxygen gas also improved seed germination; however, the increase was non-significant. Ybema (1984) found similar favourable effect of O_2 gas treatments on seed germinability. Hot and cold water pre-soaking treatments on the other hand reduced germinability of the 8 moth stored seeds. This could be either due to soaking injury or due to temperature of water or both working together cumulatively. Harmful effects of hot water treatment on cotton seed germinability has been reported by Abd-El-Rehim *et al.* (1969). Harmful effects of imbibational chilling treatments have also been observed in cotton, soybean, limabean and maize (Murray, 1984).The injury is reported due to the leakage of electrolytes from seeds that are cold sensitive and also due to destruction of normal degree of compartmentation with in the cell organelle. Joshi *et al.* (1980) have reported that pre-soaking improved germination of dormant groundnut seeds but had negative effect on the germinability of non-dormant seeds stored at $24 \pm 1°C$. The groundnut seed lots used for present investigation was non-dormant

Various treatments showed highly significant differences in protein content in the embryos of the germinated seeds (Table 1). First four treatments which had promoted seed germination, had significantly higher protein content compared to control. The last two treatments, hot and cold water, had significantly less protein content compared to control. This difference in protein content inthe germinated embryos might cause difference in seedling vigour in different treatments. As compared to germinated embryos, ungerminated embryos showed less protein contents after 5 days of germination. However, differences between protein contents of germinated and ungerminated embryos were not large particularly when seeds were treated with hot water, cold water or kept untreated i.e. control. This indicated that protein synthesis in germinated and ungerminated embryos did not differ much in seed lots with lower germinability. Results obtained are in confirmation with the results of Saxena (1979) who demonstrated that protein synthesizing capacity of the embryos was related to germinability of the seeds in soybean.

It was observed that those treatments which improved germinability also improved enzyme activity in cotyledons, Treatments showed highly significant result in respect of -α amylase activity. Gibberellic acid, alcohol vapour, H_2O_2 and O_2 gas showed a descending trend in α -amylase activity, all being significantly higher than the α -amylase activity of control (Table 2). Hot and cold water treatments reduced enzyme activity.

Isocitrate lyase is the key enzyme for the conversion of stored lipid on oilseeds to easily respirable carbohydrates in the germinating grain. The enzyme activity was favoured by germination favouring treatments. Alcohol vapor and gibberellic acid treatments had significantly higher isocitrate lyase activty than the control seeds. The difference in enzyme activity of other treatments with the control was non-significant. The lowest values for isocitrate lyase activity was observed in hot water treatment.

TABLE 2. ∝ -amylase (△.O.D./min/mg protein), isocitrate lyase (nmole glyoxylate released/hr/mg protein) and peroxidase (△.O.D./min/mg protein) activities in the cotyledons of germinated seeds after 5 days of imbibation as influenced by bioregulatory treatments.

Treatments	Enzyme activities		
	∝ -amylase	Isocitrate lyase	Peroxidase
Alcohol vapour	0.297	2.43	0.348
Gibberellic acid	0.308	1.92	0.304
H_2O_2	0.248	1.24	0.277
O_2	0.227	0.94	0.225
Control	0.125	1.00	0.221
Hot water	0.120	0.58	0.092
Cold water	0.117	0.71	0.064
S.Em.	0.127	0.195	0.0408
C.D. (0.05)	0.0384	0.59	0.1237
C.V. %	10.0000	34.40	32.3000

Germination improving treatments e.g. alcohol vapour, gibberellic acid, hydrogen peroxide and oxygen gas had higher peroxidase activity in descending order (than the control), although the difference was significant only for alcohol vapour treatment. Hot and cold water treatments had significantly lower peroxidase activity than control.

The results show that several treatments like alcohol vapour, gibberellic acid and H_2O_2 significantly improved the germinability of Summer groundnut seeds. Those treatments which improved germinability also increased ∝ -amylase, isocitrate lyase and peroxidase activity in the cotyledons of germinating seeds. Protein synthesis in embryonic axis was favoured by germination emproving treatments compared to germination inhibiting ones.

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A NOTE ON THE EFFECT OF NATURAL AGEING AND ASSOCIATED BIOCHEMICAL CHANGES IN SUMMER GROUNDNUT (*ARACHIS HYPOGAEA* L.), Cv:GG-2

The seeds of groundnut in Rabi/Summer season have been reported to lose viability when stored under ambient condition of temperature and relative humidity (Anon., 1986). This causes higher seed rate and uneven plant stand in the field resulting in higher cost of production and less profitability. The Summer groundnut faces higher temperature and relative humidity during the early part of storage period (June-October). This causes the seed to deteriorate quickly. The general loss of viability in Summer groundnut due to electrolyte leakage as well as leakage of organic solutes through damaged membrane is well known (Parameswaran *et al.*, 1988). But associated biochemical characters, like the change in phospholipid content due to seed membrane damage or loss in key enzyme like isocitrate lyase activity in groundnut have not been worked out so far. In the present work extent of change of such characters have been evaluated and reported.

Summer groundnut seeds (Cv:GG-2) of May, 1987 harvest grown at the experimental farm under recommended package of practices, were stored for one year in gunny bag in the form of pods at ambient temperature on cement shelf. Fresh seed lots of GG-2 was collected from May, 1988 harvest from the same experimental field under the same management practices. These two seed lots were compared for germinability, isocitrate lyase activity and phospholipid content in May, 1988.

After surface sterilization with 0.1% $HgCl_2$, groundnut seeds were germinated under standard condition as per ISTA rules (Anon., 1976). Germination tests were conducted in triplicate with 50 seeds in each replication. Isocitrate lyase activity was determined from the fat-free endosperm according to Smith and Gunsalus (1951). Phospholipid content was estimated by following the method of Agrawal (1987). Standard curve was prepared with phospholipids isolated from groundnut by column chromatographic method (Rouser *et al.*, 1967). Isolated phospholipids from fresh and aged seeds were separated by thin layer chromatography (Rouser *et al*, 1969).

Results show that germinability was drastically reduced after one year of storage (Table 1). Isocitrate lyase activity measured from the germinated seed cotyledon also showed accompanying loss of activity along with seed deterioration. As a key enzyme of glyoxalate cycle which is important in providing a link between fatty acid degradation and the synthesis of new cell constituents during germination, isocitrate lyase activity would be one of the important factors governing germinability of oilseeds., Fu *et al.* (1988) have suggested that during seed deterioration, the isocitrate lyase enzyme synthesising mechanism involving nucleic acid is deteriorated. Total phospholipids

TABLE 1. Effect of natural ageing on per cent germination and isocitrate lyase (n mole glyoxalate released/hr/mg protein) and phospholipid content (%) in fresh and one year old seeds.

Parameters	fresh seed			One year old seed		
Germination %	94.7	±	0.545	10.7	±	2.18
Isocitrate lyase	1.459	±	0.102	0.675	±	0.017
Phospholipids	1.09	±	0.08	0.82	±	0.04

Values are mean ± S.Em. of three observations.

TABLE 2. Thin layer chromatographic separation of phospholipids in groundnut seeds.

	Fresh seed	Aged seed
Phospholipids	R_f	R_f
Phosphatidic acid	0.32	—
Phosphatidyl choline	0.59	—
Phosphatidyl ethanol amine	0.89	—
Unidentified	0.96	0.94

contents of old seeds showed a deterioration change over fresh seeds. Not only it reduced in quantity (Table 1); there was also a qualitative change of phospholipid moieties as determined by thin layer chromatography (Table 2). Phosphatidic acid, phosphatidyl choline and phosphatidyl ethanol amine declined with ageing and loss of germinability. Halder *et al.* (1983) also reported decline in total phospholipid content, phosphatidyl choline and phosphatidyl ethanol amine in aged seeds of sunflower. Pearse and Samad (1980) reported that membrane lipids are lost during storage of groundnut. In the present investigation also total phospholipids, phosphatidyi choline, phosphatic acid and phosphatidyl ethanol amine levels were found to decline on ageing indicating that such loss of phospholipids might be leading to loss of subcellular compartmentation resulting in poor viability in groundnut seed.

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